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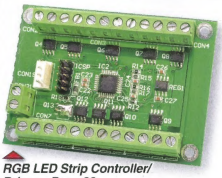

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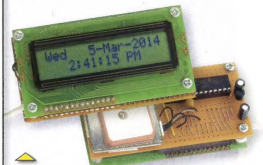

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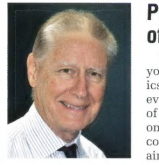
Publisher's Letter



Planning for future disposal of your assets

This is a sombre subject to discuss: what will happen to your favourite things when you move to that big electronics workshop in the sky? The reason I raise this is because every now and again I receive an email from the spouse of one of our recently deceased readers, asking for advice on how to best dispose of their husband's vintage radio collection, test equipment, tools, books, model train/car/aircraft/ship collection or whatever.

The problem is that during a lifetime in electronics, one can acquire a vast collection of all sorts of stuff which may have considerable value to someone with a technical background but probably zero value to anyone without such knowledge. Say you have a large collection of vintage radios. Some of those radios could be worth thousands of dollars and the whole collection could be worth much more. Some of the smaller vintage radios in your collection may look like ugly lumps of plastic to most people but such ugly lumps might be quite valuable. Who would know?

Doubtless you may have a fair idea of your collection's worth and you may have paid quite a lot of money over the years to acquire it. But does your spouse know this? I will bet not.

Or if they do have some glimmer of what it's worth, do they know which collectibles are really valuable and which are not? Is it all catalogued? Probably not. The situation is worse if you live alone and upon your demise your children or other relatives are likely to be confronted by a large miscellaneous collection of what to them is just "stuff that the old man used to potter about with".

Such "stuff" just might be summarily consigned to the tip in the inevitable clean-up in the winding up of your affairs. I speak from experience. Just recently I was in the home of one of my recently deceased relatives who had been ill for a long time. The house really had not been maintained or properly cleaned for years but it did contain valuable items and one such was a small nondescript vase in a display cabinet. That nondescript vase was by Clarice Cliff and was quite valuable. Few people would recognise it. What similar items do you have?

The unfortunate fact is that many spouses only have the sketchiest knowledge of their household assets, liabilities and so on, let alone any knowledge of the value and extent of a collection of technical stuff. So you need to address the problem of how your spouse will best dispose of your stuff. After all, statistically, you will be the first to depart (if you are a bloke!) and she will be left with the problem. Or maybe your children will. Will they even care?

So first of all you need to decide what is important and what can be disposed of now. Then you to need to catalogue it. This doesn't have to be fancy; just a list and estimated values would be a start. A photo and brief technical description of each item would be even better. Then your spouse needs to know where this information is kept (easily accessible, in a filing cabinet with labelled folders!).

This could be a fair amount of work but you owe it to yourself and your spouse. To yourself because presumably you don't want your collection to be simply junked or given away. Second, you owe it to your spouse because it may contribute a reasonable sum to their welfare in the future. Finally, you need to provide some information on how the collection can be sold in order for that value to be obtained. Don't leave it to chance because that will probably lead to a poor result. Oh, and your spouse should do the same for jewellery, bric-a-brac, furniture and so on.

So go through it all. Get rid of junk that you will never use. Dispose of those units you have been hanging on to, to fix up when you "get round to it". Clean and polish the "good stuff", catalogue it and then display it so you can get the most enjoyment from it. Who knows, such a process might even rekindle enthusiasm for an enjoyable pastime.

Leo Simpson

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Extrapolation in climate change models is unacceptable

The Publisher's Letter in the April 2014 issue was about the cost of green energy and I agree. However, I wish to remind you that I sent an email to you in May 2010 in which I used solid physics to show why the Earth's temperature has not risen dramatically. In fact, it will not rise significantly unless we increase the rate at which we consume coal, oil and gas.

In short, if we wish to increase our energy consumption and not increase the Earth's average temperature, we must use solar, wind, hydroelectric or plant-based sources. But as they are so uneconomic compared with the carbon-based fuels, we need substantial cost reductions to use these alternatives.

With the respect to the climate change debate, allow me to throw a technical spanner into the argument. I am not a proponent of climate change being a certainty. I do not know what the future holds. However, I do have a serious accusation to throw at those with their climate models.

When I was studying years ago, it was made clear to me that extrapolation was absolutely unacceptable. There was no method in which a set of data points could be extended past the measured limits with certainty. It was very bad and irresponsible science.

Now, many years later and with "infallible" computer models, scientists predict the future, ie, extrapolate past their set of data points. Considering that the original taboo was for relatively simple systems, how much worse is extrapolating for the extremely complex weather system?

Also, climate change is advocated as if it is a certainty. Well, the weather is different to that of previous years but is not that much different to when I was young. From the point of view of someone who has used feedback systems, I see an unstable system. I would rather use the term 'Global Weather Instability' than climate change. Anyone with experience of feedback systems should recognise the random highs and lows of aperiodic oscillation.

I can suggest a cause for the oscillations and the best way to explain is by an example. Suppose I throw a pebble into a pond. There will be a small disturbance resulting in small ripples which will disappear relatively quickly. If I throw a large rock into the pond, there will be large waves which will interfere with each other, producing seemingly random highs and lows. Because of the large amount of energy and low viscous dissipation, the disturbance will last for a very long time.

Looking at the Earth's weather, I believe something has caused a major disturbance somewhere on the Earth's surface and I believe that something could the industrialisation of China. I do not accuse them of doing anything wrong. It is just an effect of the generation of a large amount of heat as an industrial nation. The same would have occurred for earlier industrialised nations but no one took notice at the time.

The question remains as to the nature of the future weather. Will it remain the same or will it change permanently? It is unpredictable provided honest science is applied.

George Ramsay,
Holland Park, Qld.

Evidence of climate change is overwhelming

Leo Simpson obviously has a problem with climate science, as evidenced by the Publisher's Letter in the April 2014 and other issues. Like other 'climate sceptics', Leo seems to ignore the overwhelming evidence of climate change and latches onto the snippets that seem to support his case. These have all been comprehensively de-

Using a DAC for better TV sound

I read with interest the question about DAC performance in the Ask SILICON CHIP pages of the April 2014 issue, as I had the same problem.

I purchased a set of Sennheiser wireless headphones with analog-only inputs and wanted to run them from the optical output of my 3-year old Samsung TV using the Jaycar DAC. This allows volume control independent of the speaker output of the TV as well as providing better quality. The default setting of the TV produced the same result as obtained by R. P., ie, the sound only worked on the HD channels (except SBS HD). This was easily fixed using the Samsung menu.

While it is true the menu item "broadcast audio options" can only be set to MPEG, there is another setting which applies. On my Samsung TV, the same menu has an item "additional settings". Selecting this will take you to an item called "SPDIF output". Select this and an item called "audio output" appears which will be set to Dolby. Using the arrow key, this can then be changed to PCM.

Using this setting, all channels then provided high-quality sound. I am very pleased with the result and use the headphones in preference to the standard speaker as the sound quality is far superior. I would recommend the Jaycar DAC for this application as it gives good results for a reasonable price.

Brian Day,
Mount Hunter, NSW.

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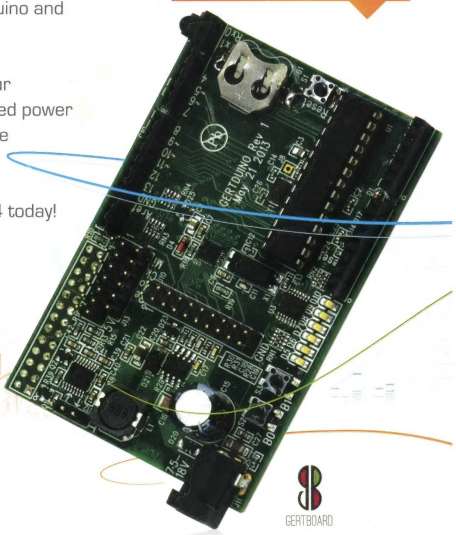

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Mailbag: continued

LiPo battery fires can start a conflagration

In view of the articles printed in SILICON CHIP over recent years regarding the dangers of charging LiPo batteries, I thought the following may be of interest. The original article came from the latest Shoalhaven Model Flying Club newsletter.

One of the club members was going home after a days flying and was stopped by police at a road block in Arana Hills. The police and fire brigade were dealing with a situation that required vehicles and people be kept well away. Apparently a modeller from the same club who lived close by was charging one of his many 1kg LiPo batteries which caught fire in his house, ignited a gas bottle which exploded and in turn started a huge fire.

The house had to be boarded up and temporary fencing has been erected. There was extensive fire damage to the garage and guttering above the boarding. Fortunately the fire was contained and the rest of the house was saved. The house is presently unoccupied due to the severity of the damage until it can be repaired.

Again, I cannot emphasise enough the dangers of charging LiPo batteries in confined spaces, particularly when there are other flammable materials close by.

As it wasn't at a model airfield and no claim was made through MAAA insurance, most modellers wouldn't know about it, hence this warning to help get the word out.

Bob Young, UAV Consultant, Riverwood, NSW.

bunked – see www.skepticalscience.com/graphics.php

If Mr Simpson cannot understand the (admittedly) esoteric global statistics perhaps some 'on the ground' examples, closer to home, may be more convincing.

As an agricultural consultant in southern Australia, I am on the front line with those who have to deal with the day to day reality of climate change. For farmers, these changes are not in some vague future decade. They began to be obvious in the 1960s when winter rainfall started to decrease. In 2014 it is down 20% in most places.

For cereal farmers, reduced winter rain means reduced yield. At the same time, summer rain is increasing as tropical low-pressure systems now drop their load in southern states (as predicted). This is useless to cereal farmers and a menace to grape growers.

But it is not just rainfall. The tiny temperature rise we have seen since 1950 has been enough to wipe out the apricot industry in the river-land. Foreign imports did damage the industry but the reality is that temperature rise in the river-land is now enough to make the fruit ripen before it has filled out properly. We can no longer grow apricots in a region which was a major world supplier in 1970.

Similar things are happening in the wine industry – vines are flowering too early and ripening too fast. Grape growers watch (and record) their weather *very* closely – it has a major effect on the quality and quantity of their product. Those who want to be in the industry long term are now moving to cooler locations. One national brand western Victorian producer is moving to Tasmania – the final impetus to the move came when they recorded 22 successive months of record temperatures.

The costs of these and other changes are a little more subtle than a monthly power bill but they affect city dwellers in that quality produce is less available and more expensive. Plant breeders are scrambling to produce new varieties, more suited to the new climate but this is not done quickly or without big cost to the community.

Millions of dollars spent by governments to clean up after more frequent floods, fires, and droughts come from every taxpayer. Your power bill, Mr Simpson, is a tiny, tiny, component of the cost of climate change to you.

Unlike river-land orchards, some of the incentives in moves like the carbon tax ARE bearing fruit. The cost of most solar energy systems has nearly halved in a decade (unlike nuclear power costs).

The USA has just completed a new, grid scale, concentrated solar power system at a cost of $5000 per kW installation cost – running cost near zero and decommissioning cost near zero (http://en.wikipedia.org/wiki/Ivanpah_Solar_Power_Facility)

They are also building a modern nuclear power station (at Vogtle, Georgia) at $5000 per kW installation cost (if they stick to budget) – running cost substantial, decommissioning cost massive, cost of spent fuel handling massive and long term.

I would suggest that for sunny countries, nuclear power is no longer an option – solar is cheaper as well as safer! Perhaps a dollar or two of your power bill contributed to this result.

Cliff Hignett, Naracoorte, SA.

Comment: whether or not global warming is occurring really has nothing do with the fact that green energy schemes are too expensive and will do little to ameliorate the effects of climate change.

Solar power for all homes would be good

As I was reading Leo Simpson's Publisher's Letter in the April 2014 edition of SILICON CHIP, I could only hope it was an "April Fool" letter. Or maybe it wasn't?

Yes, I have been dismayed at the rising energy costs and that is why I have installed solar power on my house. My business is based at home so my maximum power usage is during the day. The 10kW solar power system installed on my house allows me to run air-conditioning during the day for free. It is very pleasing to see the graphs of my power purchased from the grid flat-line during the day.

My belief is that all houses should have solar power installed. What is Mr Simpson's problem with solar power installation owners receiving a feed-in tariff? I wonder if Mr Simpson has shares in the power company? Our electricity supplier has resold my feed-in power for over $2000 with no cost to them, so what is his problem? The feed-in tariff is way too low now, at a pitiful 8c/kWh, so the old argument

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Mailbag: continued

Publisher's Letter was not a joke

The Publisher's Letter for the April 2014 issue now seems appropriate for the first day of that month. Perhaps it was written in jest, to see if we would recognise the April Fool's joke.

A recent announcement by the Australian Energy Regulator once again confirms the fact that gold-plating and subsequent overcharging by network operators is the main cause of power increases, which directly contradicts your editorial. You continue to push the Tony Abbott line which alleges that increases in power prices are almost totally the fault of the RET and those terrible green initiatives to encourage the use of solar and wind power.

The Australian Energy Market Commission (a government body) provides statistics which clearly show that the RET is the single smallest component of electricity bills (bar one) and is declining in proportional terms. The Australian Energy Market Regulator's report for 2013 states the following: "There have been many large changes in the relative and overall magnitude of the charging parameters within the period. Of particular note is the 471.14 per cent increase in the fixed charge in 2012-13, 18 per cent decreases in energy charges in 2006-07 and over 200 per cent increases in energy charges in 2009-10." These figures are not opinions, they are facts which can be confirmed by referring to government reports.

The Publisher believes we should continue to use coal-fired power stations to the maximum, because they are "the cheapest alternative" and because you don't accept the evidence for global warming. Again, the IPCC report shows that coal-fired energy generation is the single largest contributor to global warming, a fact that has been reported previously and is supported by 97% of the world's scientific community. Apparently, you support the scientific consensus on electronic theory but choose to scorn a consensus that disagrees with your political beliefs.

Chris Peters,
Eltham, Vic.

Comment: coal-fired energy generation may be the single largest contributor to increasing carbon dioxide in the atmosphere. Whether any global warming is presently occurring is the subject of furious debate. In any case, none of the IPCC reports are supported by 97% of the world's scientific community. That figure is a hoax.

that non-solar users are subsidising those who install solar power only applies to a relatively few early systems, that would generally be quite small.

On our previous home we did have a 1.6kW system on the 60-cent tariff but that was five years ago. We got very little back from that system while we were living there as our power consumption used it all up most days. Leo Simpson obviously is a climate change sceptic. I cannot understand how anyone can hold that view but each to his own.

Notwithstanding, the argument that Australia should chuck out all steps aimed at reducing global warming just because our footprint is so small is a small-minded attitude. How can we try to encourage others to look after our world if we are not willing to put our admittedly small paddle in to help? Mr Simpson's comment indicating that global warming is a myth because of the extreme northern winters further shows his lack of understanding of the problem.

Global warming will cause increasing extremes of the climate, not just things getting hotter. It does look like Mr Simpson is primarily concerned with dollar cost and nothing else.

Sticking to only fossil fuel to generate power is cheaper in the short term but in the long term, it will be pretty disastrous. But going nuclear is not an option as we have seen from various failures around the world. Even a faint possibility of an Australian nuclear power station having a meltdown such as already happened in Chernobyl, Fukushima and Three mile Island should cause anyone to reject the option of nuclear power coming to Australia.

I look forward to a better battery technology so I can go off-grid altogether.

Denys Parnell,
Shepparton, Vic.

Comment: the last 40 years have not seen increasingly extreme weather events; quite the opposite.

High feed-in tariffs and the RET scheme penalise all electricity consumers who cannot afford the investment for a solar panel installation. Going off-grid is a good choice for those who can afford to do so.

Telstra mobile phone service interrupted by masthead amplifiers

The following extract is taken from "The Monitor", 26th March 2014, a local paper in Roxby Downs, SA (the full article can be viewed at www.themonitor.com.au): "Telstra service interrupted by amps – 26-Mar-2014, Millie Thomas. Incorrect installation of television masthead amplifiers in Roxby Downs' households has caused the prolonged, consistent interference in the local Telstra mobile network. The interferences have been occurring in Telstra mobile phones in Roxby Downs for a number of months, and include interrupted mobile internet browsing, trouble making outgoing calls, and frequent call drop outs.

Telstra Country Wide (SA North and West) General Manger John Tonkin said Telstra has had technicians up in Roxby Downs investigating the issue."

A business that performs work, as in the article, should be named and shamed as it shows a complete lack of understanding of TV and RF distribution as well as a lack of knowledge of installation and testing principles. Forget about the applicable standards, requirements for radiation compliance, professionalism, qualifications and experience.

It is extremely hard to compete with businesses that provide a service of this level when actual professionals have invested in the qualifications, training and the applicable test equipment. I bet their charge-out rate is near industry standard and if asked,

it would be qualifications and training used to justify the rates!

For many years we have heard the electrician versus technician debate (sometimes quite heated) but both are at least qualified, where as now I am becoming concerned with the increasing belief that an ACMA licence is a qualification, specifically as that is all that is required to promote yourself as a Data, Electronics or Communications Company!

This is nearly as annoying as being in an OH&S Lecture where a 12V DC 500mA power supply was identified as capable of stopping your heart!

Greg Budden, Outback Data & Communications Pty Ltd, Woomera, SA.

Avoid cheap LED replacements for halogen downlights

I have a few comments on the "Questions On Halogen Lamp Transformers" item on pages 92-93 of the April 2014 issue. First, using "electronic transformers" (cheap and nasty switchmode power supplies) can, as you point out, lead to early failures because of the poor quality of the output, which a halogen doesn't care about but a LED does. A much bigger problem is that some switchmode supplies require the load characteristics of a halogen in order to start and won't work with the very different load from a LED, or may work with flickering light, buzzing or other unpleasant side-effects.

The transformers also have an output of 12VAC (meaning 40-80kHz switching noise in a 100Hz envelope), which isn't ideal for a 12V DC LED. Proper LED power supplies produce a generally "DC-ish" output, although again not perfect because the manufacturers skimp on filter capacitors so there's a fair bit of ripple.

Buying cheap LEDs direct from China may save you money but will (at least in New Zealand) run foul of electrical safety regulations. If the lights are installed in an enclosed space covered by insulation then they have to be rated as such (IC-F rated in NZ, meaning they won't overhead/catch fire/lose you your insurance cover) which needless to say, none of the direct-from-China imports are. In addition, the rated lights will come with LED-appropriate power supplies attached, so you don't need to worry about whether things will work with left-over halogen parts.

Another problem with cheap LEDs is that it's more or less impossible to ensure colour purity across different batches, meaning you have to buy all the LEDs you're likely to ever need in one batch to make sure you don't end up with a mixture of yellow, blue and green tints. I've seen this with "upgrade-over-time" installations and it looks really bad.

I went with the cheapest IC-F rated ones I could find, @ $49 for a 5W light, which nicely replaced a mixture of 60W incandescents and 50W MR16s that some fiend had installed at some point in the past, dropping the load to one tenth of its previous amount while actually increasing the light output.

Peter Gutman, Auckland, NZ.

Freed-Eisemann coffin radio

I thoroughly enjoyed the Vintage Radio column in the February 2014 issue on the Freed-Eisemann NR7 radio and thought you may be interested in a Freed-Eisemann set that I have in my collection.

Mine is the even older NR5 model which, according to the Radio Museum website, was the first Neutrodyne set produced by the company. It was manufactured between April 1923 and October 1924. The NR6 followed in late 1924 and the NR7 in 1925.

The NR5 is very similar in design to the NR7 with just minor differences. It uses only five UX201A valves, has two output jacks on the front panel and doesn't have an on/off switch as such but is turned on by inserting a plug into one of the output jacks. Depending on how loud you want the volume, you plug a speaker into either the first or second audio output jack. The tuning condensers, coils, dial knobs and cabinet are the same as those used for the NR7.

I purchased my set about five years ago off eBay, the seller stating that the set was in fully-restored condition. I have to say that apart from a couple of minor details, it appears to be in almost perfect original condition, which is amazing considering its age. Even the operating instructions and station log card on the underside of the lid and the battery connection card on the rear panel are in nearly perfect condition.

I'm guessing that this set may have been pensioned off fairly early in its life to make way for a better performing and more user-friendly superhet. It appears to have been put away in a cupboard somewhere and was there virtually ever since.

With reference to the second paragraph in your article, the last sentence on the battery connection card reads: "The manufacturers will be pleased to hear of the results obtained with this Neutrodyne receiver". They obviously wanted feedback from their customers as to the performance of their radios. They needn't have worried, as no matter how you look at them they are obviously very well-designed, craftsmen-built radios.

Ron Barnes,
Otago, Tasmania.

Hybrid cars will continue to be sold

I would like to comment on the letter from Dr Kenneth Moxham in the February 2014 issue, titled "Camry Hybrid Is A Pleasure To Drive", responding to the Publisher's Letter in the November 2013 issue, "Hybrid Cars May Not Endure". I would also like to discuss my experience with electronic vehicle technologies in general.

I think to an extent they are both right regarding hybrids. Stop/start technology is eroding the fuel economy advantage a full hybrid has over a regular internal combustion engine (ICE) powered vehicle. Let's not forget about diesels too. These can have even better fuel economy than hybrid petrol-electric cars although with their own issues; I am especially concerned about particulate emissions which still seem to be a problem, even with modern European diesel passenger cars (for

example, the recent severe smog in Paris). Nitrous oxide emissions from diesel engines also appear to be much worse than petrol engines.

There's also the issue that hybrids are most at home in the city where there is a lot of start-stop driving. Out on the freeway, they don't really offer any better fuel economy than a regular petrol car and in fact are quite significantly worse than a good diesel. I've done the sums and even in the city, you'd have to drive something like 200,000km to save more on petrol than you pay up-front for a hybrid.

So clearly the reasons to favour a hybrid are other benefits such as the ability to move silently at low speeds (which not so great for pedestrians though!). I think they will continue to be sold but unless there is a major breakthrough in battery technology, will not get a large share of the market.

You mention that reducing weight improves fuel economy and this is undoubtedly true but it's unlikely to happen. There are various factors which have led to modern cars weighing more than their predecessors, including safety equipment (especially reinforcement), more rigid frames and better suspension to improve handling, larger wheels and tyres (a fad, although wider tyres certainly do offer improved grip), more technology and more comfort (soundproofing, electric seats etc). Most people aren't going to give up safety or comfort to save a few dollars worth of petrol a week. I certainly wouldn't.

Yes, the use of materials such as aluminium and carbon fibre can reduce weight but these increase cost and cause other problems, eg, carbon fibre can be difficult to repair. And vehicles which do make use of aluminium tend not to be that light because they're doing it in order to compensate for other heavy items. For example, the Jaguar XJ has an all-aluminium body but still weighs nearly 1.8 tonnes.

As well as hybrid technology, a whole host of new technologies are being deployed in vehicles and I feel that we will be seeing them right across the board in just a few years' time. My

TMS2000 soldering station cannot drive two hand-pieces at once

I enjoyed your excellent review of the Thermaltronics TMT-2000S-K Soldering Station in the April 2014 issue. I use a 9000 series at home and in my work situation and have nothing but praise for them.

There is just one error in your review though. The caption to the small picture showing two hand-pieces says that the unit can power both at once. My 9000 has two sockets but each is selectable; only one outlet can be used at a time.

A quick email to Thermaltronics confirmed that the 2000 is the same; only one outlet at a time can be used. It is a pity you could not have expanded your review to the desoldering attachment, which is also an excellent device.

Tom George,
Ballarat, Vic.

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Mailbag: continued

recent decision to buy a new car was largely based on the improved technology compared to the previous model (just a few years old), now available at a reasonable price.

This package included radar-guided adaptive cruise control, collision-mitigating braking and warning system, emergency brake assistance, trailer stability assistance, emergency stop signal, lane-keeping assistance, high-beam assistance, a blind spot camera, reversing camera, auto-dipping rear view mirror, hill start assistance, LED headlights (low-beam), cornering lights, LED daytime running lights and brake lights, a fuel consumption/range display, tyre deflation monitoring and road ice warning.

That's a lot of electronics! And it's in addition to some of the great features carried over from the last model I owned including an excellent electronic stability control (ESC) system with electronic brake-force distribution (EBD), rain-sensing wipers, automatic headlights plus the always useful front and rear parking sensors.

While prospective buyers will generally consider a car's safety rating when purchasing, as far as I know, this is just an indication of how well the vehicle protects the occupants in a collision (and then only in comparison to vehicles in the same class). It says nothing about the likelihood of a collision which of course includes driver skill, attentiveness and luck. But consider that the above-mentioned electronic systems help to keep you out of trouble while driving. And I must say they generally work extremely well.

I have now had a chance to try them all and found that mostly they work very well and many of them are a great boon to safety. The adaptive cruise control is great for long trips and I've driven for hours at a time (between Sydney and Melbourne) without having to touch any of the pedals, even with light to moderate traffic. I can sit behind a vehicle going close to the speed limit and my car will automatically follow at a safe distance. If they brake, it will brake too.

I also used the lane keeping assistance extensively on these trips and it both reduces driver fatigue and prevents the vehicle going off the road in a moment of inattention.

The collision mitigation braking and warning system is effectively an extension of the radar-guided cruise control but it is always active. It will warn you if an object is rapidly approaching and if you do not react, it will brake for you. It will also pre-tension the driver and passenger seatbelts if it thinks a collision is imminent. When the brakes are fully engaged (whether manually or automatically), it flashes the hazard lights to warn vehicles behind you, so they (hopefully) don't run into you.

The blind spot camera is brilliant and I think the days of external rear-vision mirrors are numbered. It gives a much better view than the normal passenger-side mirror and is much clearer and more convenient to glance at. Reversing cameras are also great, provided they are of sufficient quality (not all are). Some cars now have 360° camera coverage for parking.

High-beam assistance automatically dips the headlights when lights are detected in front of your vehicle and this

More coal-fired power stations being opened in Germany

With respect to the Publisher's Letter in the April 2014 issue, are coal-fired power stations shutting down overseas? No and they're not likely to! With Germany shutting down their nuclear power stations, they have gone back to coal fired-power. Why? Apparently it costs too much to dispose of radioactive waste and they're seen as dangerous.

In fact, the German green revolution has been so successful they have just 'test-fired' five new coal-fired power plants with a combined capacity of around four gigawatts – see http://www.platts.com/latest-news/coal/london/analysis-german-4-gw-new-coal-plants-in-testing-26170384

And just in case the wind stops blowing or the sun is blocked by clouds of evil man's 12 parts per million colourless, odourless, trace gas carbon dioxide, rendering their half a trillion euro investment in windmills and solar panels useless, Germany have another 15 coal plants planned to open by 2020 – see http://wattsupwiththat.com/2013/04/23/germany-to-open-six-more-coal-power-stations-in-2013/

John Vance,
Wangaratta, Vic.

works very well for night driving on the freeway, again allowing you to concentrate on the road rather than fiddling with a stalk. The rain-sensing wipers provide a similar advantage, especially in changeable weather or stop/start driving.

I won't go into detail about the other systems mentioned above but I will say that I've found them all to provide incremental improvements in safety, awareness and ease of driving and they are worth paying for.

E. Murdoch,
Randwick, NSW.

Global warming & climate Change

Reading the Publisher's Letter in the April 2014 issue leaves me rather concerned for the following reasons.

(1) "Cherry picking" of data to suit a person's point of view is not a valid scientific process.

(2) Neither is denigration and ridicule directed towards others who have opposing opinions on a valid scientific process.

(3) Global warming and the associated climate change is upon us. To claim remedial action is too costly for Australia and do nothing is to deny our global responsibility.

(4) Procrastination will only result in increased remedial costs at a later date.

We need to understand the following facts:

(1) The major input of heat energy into the Earth's atmosphere comes from the Sun.

(2) Atmospheric and oceanic circulation patterns distribute this heat energy across the Earth's surface as weather.

(3) Climate is the sum of weather patterns in a given geographical area.

(4) Carbon dioxide is a known greenhouse gas.

(5) The atmospheric carbon dioxide level is increasing due to human activity.

How are these facts significant?

(1) Short wavelength infrared radiation from the Sun passes through the Earth's atmosphere to heat the Earth's surface. Infrared radiation from the Earth's surface has a longer wavelength that is absorbed by carbon dioxide and other greenhouse gasses in the atmosphere.

(2) Increased carbon dioxide levels in the atmosphere results in increased absorption of infrared radiation from the Earth's surface thus raising the Earth's atmospheric and surface temperatures. The result is global warming.

(3) Existing atmospheric and oceanic circulation patterns must change to redistribute the increased heat energy in the atmosphere. The change can be in intensity and/or distribution of these flow patterns

(4) Associated with these altered circulation patterns will be the redistribution of water precipitation and atmospheric temperatures.

(5) Climate change is the result of these changed circulation, precipitation and temperature patterns.

Where to now ?

(1) Here lies the problem: the Earth's surface temperature is not yet in equilibrium with the increased heat energy absorption by the atmosphere.

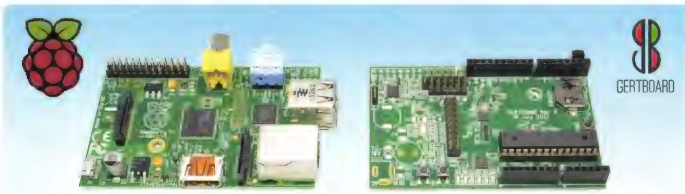
(2) There is a phase lag between heat energy input to the atmosphere and surface temperatures as evidenced by the fact the warmest days occur after the local summer solstice and lowest temperatures occur after the local winter solstice.

(3) Even if atmospheric levels of carbon dioxide could be held immediately at their present levels, global warming and climate change would continue until the Earth's surface temperature rose to the level where outgoing infrared radiation would equal the incoming infrared radiation from the Sun. Then and only then would the Earth's global surface temperatures stabilise.

(4) Energy efficiency and renewable energy sources are the only real solution as the Earth itself is a finite resource and nuclear energy has the major problem of radioactive waste storage and the long term contaminating result of nuclear "accidents".

Finally, think of the jobs that could be created by initiating, developing and maintaining energy efficiency procedures and renewable energy resources.

Col Hodgson,
Mount Elliot, NSW. SC



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Android Apps for Tech-Savvy Users

With an Android smartphone, you can do so much more than make calls or send texts. For anyone into electronics, it can virtually be a test bench in your pocket. And then some!

Remember when telephones sat on the desk or table, connected to the wall socket via a cable? And all they could do were make voice calls?

Quaint as that may seem today, as little as 25 years ago it was said many countries were so deprived of wired infrastructure that half the world's population (mostly in African and Asia) had never heard a phone ring.

From the mid 1990s however the mobile phone, initially brick sized and oh-so-expensive, rapidly changed that!

Plummeting size and price and improved battery life increased mobile phone uptake to the extent that it's now rare to go to an urban area almost anywhere on the planet and not have cellular phone coverage.

Prices have fallen so low (in some places as low as ~$10 for basic models) that ownership can be justified for even children and the impoverished.

Home (fixed line) phone installation continues to fall – many people, particularly the younger and more "mobile", rely solely on mobile phones, eschewing fixed line models and their rental and call costs.

Even then, users often consider their near new mobile phones obsolete in as little as a few months and upgrade... in fact e-waste issues increasingly arise.

Convenient as mobiles may be, for a good decade most were essentially just intended for voice or text messaging, with the internet's parallel development almost co-incidental.

It's only been in the last ten years that more versatile 'smart phones' have emerged.

Although Apple's iPhone lead with their mass offerings, Google's cheaper and more open Android operating system approach now commands most of the market. Mass production by numerous Asian makers (especially Korea's Samsung who offer a near-bewildering range) has sent prices into near free fall.

Some two billion Android-based devices (both smart phones and tablets) are likely to be in global use by late this year!

"Smart" may well be an understatement!

Inbuilt calculators, note pads, clocks, lights, Bluetooth, WiFi, GPS, digital and video cameras, radio, music and video players, high speed web browsing, email and bright touch screens are now considered the "norm" on today's "all in one" smart phones.

Inbuilt sensors for motion, magnetic fields and light are also common. Increasingly, they have multi-core CPUs, with more processing power than a typical home PC.

Such horsepower may come with caution however, as a significant issues relate to the phones' slim batteries.

Although inbuilt rechargeable Li-Ions batteries is now the norm, ratings of just 2000mAh at 3.8V are typical.

Many applications unwittingly run "in the background", using power all the time. Unused applications should hence be turned off until needed, otherwise heavy device use (perhaps for GPS or games) may deny users even mere phone calls by day's end.

Android devices have thankfully, however, standardised on micro-USB charging sockets, so various portable and car chargers – even solar chargers – can come to the rescue.

Google Play Store

Users are not limited to their devices' initial applications. As surely anyone of tender years now well knows, Google have organised a repository of downloadable "apps" (applications) at their so-called GooglePlay site (formerly known as the Android Market). This may be accessed from either a smart phone "shopping bag" icon or via the web on another computer – – https://play.google.com.

Exploring the Google Play site from a PC may be more convenient, as keyboard and mouse browsing allows an easier overview of offerings, reviews and alternatives than a smaller touch screen. To install it on your phone, you can either connect the phone to your PC or you can simply email the app's

URL to your phone for installation at your leisure.

What apps?

More than a million apps are already available, with many either free or very low cost (ie, cents).

Significant numbers are games orientated but productivity apps abound. If you can put up with occasional small adverts – usually chopped when WiFi is turned off – then classic (& novel) e-instruments may be had for free!

Some are half-baked and of questionable appeal but they are tempting for skinflints and educational users. As most students will already have a smart phone, "BYOD" (Bring Your Own Device) versatility and bench clutter reduction benefits may arise.

A brief selection of "e-apps" (electronic apps) are considered overleaf. Several are low-frequency audio slanted and use on-phone sensors, microphone and speaker.

Given SILICON CHIP's recent mailbag correspondence re mobile coverage there's a focus on apps that have shown themselves very handy for WiFi and mobile phone setup and monitoring.

We trialled these apps on a late-2013-era, dual core Samsung Galaxy Ace 3 (GT-S7275R), under popular Android V4.2.2 "Jellybean" (Android operating system updates are alphabetically named after confectionery).

Screen grabs on this model can be made by pushing the home and power buttons together. After a few seconds a camera "snap" sound is heard and the shot is saved to the phone's photo gallery. The file can then be sent to a PC as an email attachment.

Readers are encouraged to browse Google's Play site themselves for apps that suit their specific needs.

The very nature of this extremely rapidly evolving field means the following selection may be soon dated, if it isn't already!

What, no smartphone?

For those without a smartphone (yet – don't fight it, it's only a matter of time!) but keen to wet their feet perhaps you could consider PC emulators – an overview is given here: www.makeuseof.com/tag/3-ways-run-android-apps-windows/.

Of course, a PC may lack inbuilt sensors or a touch screen!

Android phones and tablets however are so ubiquitous (with entry level models now laughably cheap) that there's really little reason to put off purchase.

Since even pre-school kids are increasingly comfortable with them, old timers should perhaps enlist their grandkids to instruct on screen swiping and selection techniques!

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IOIO Kit
The SparkFun Inventor's Kit for IOIO (SIKIO) provides 7 projects that allow you to control various pieces of external hardware with a IOIO-OTG. The kit contains: guidebook, IOIO-OTG board & cable, breadboard and electronic parts used in the guidebook
SKU: SFK-005 Price:$103.44+GST

Digit TLH
Battery powered temperature & humidity logger that can store up to 260k readings. Up to 4 year battery life. 7 log intervals, 2 programmable alarm thresholds. Download to .csv files over USB to Windows based computer. IP53 enclosure included.
SKU: LAJ-061 Price:$86+GST

Tape Shield Kit For Arduino
The KTA-292 is an easy to assemble tape dispenser for your Arduino. Arduino shield compatible. Supplied as kit, requires assembly. Red and Black electrical tape is included. Suits tape up to 40 mm wide.
SKU: KTA-292 Price:$19.95+GST

Positive Adjustable PSU
A compact, easy to use, positive variable power supply module. It is ideal for powering any application requiring a DC supply at current levels up to 1.5 amperes. Also available as a kit, negative adjustable PSU is also available. For dual-rail PSU, combine the positive and negative PSU.
SKU: PSU-010 Price:$35+GST

Ultrasonic Range Finder
5 m range, compact, IP67 ultrasonic rangefinder with 1 mm resolution. Analog voltage, pulse width and TTL serial outputs. For a limited time these are being discounted to clear excess stock.
SKU: MXS-104 Price:$99+GST

Serial Digital I/O Controller
PC-based serial digital I/O controller is designed for control & sensing applications. It features 8 relay outputs, 4 optically isolated inputs and RS-232 interface. 5 to 24 VDC powered.
SKU: KTA-108 Price:$115+GST

Arduino Motor Shield
This motor driver shield makes it easy to control 2 x 12 A (continuous) high-power DC motors with your Arduino or Arduino compatible board. It also features: current-sense feedback, custom Arduino pin mappings & accept ultrasonic PWM frequencies. 5.5 to 24 VDC powered.
SKU: POL-2502 Price:$62.95+GST

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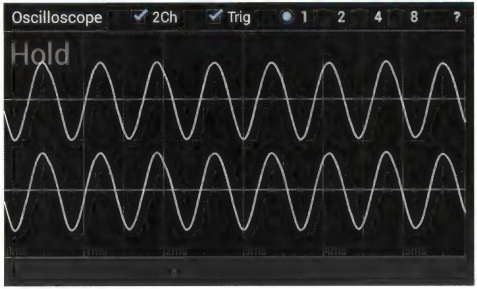
Audio Test Gear Apps

Some of these free apps are limited versions of the pay-for version. However, in most cases, the paid version is at most just a few dollars (or even cents!).



Oscilloscope

Oscilloscope

Responsive but limited to audio frequencies. With input via the microphone this app tends to entertainment value. (In a later article we hope to consider further use of the 4-pole headphone socket as a general I/O port for better CRO emulation and both sensing and serial data display.)

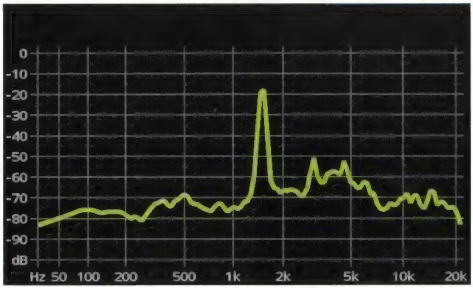
https://play.google.com/store/apps/details?id=com.xyz.scope

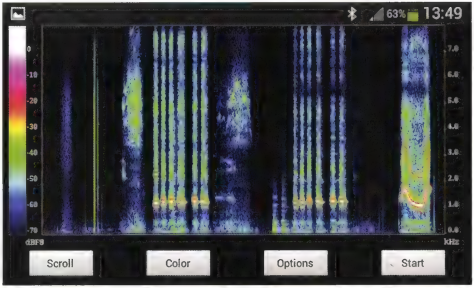
FrequenSee

FrequenSee

A high audio frequency (to 20kHz) and fast responding sound frequency spectrum display. Sensitive, but the "fat" curve detracts.

https://play.google.com/store/apps/details?id=com.Daniel-Bach.FrequenSee





SpectralView Analyzer

SpectralView

An entrancing moving "curtain" (scrolling or wrapping) audio spectrum analyser. Although restricted to 8kHz for the free version, it could suit general AF insights – noise levels and tones, bird calls, "fuzzy" audio data (sequential multiple tone Hellschreiber, etc)

https://play.google.com/store/apps/details?id=radonsoft.net.spectralview

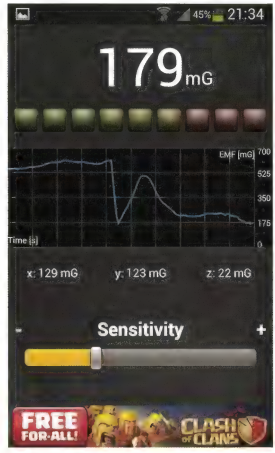
Other Test Gear Apps

PA Tone

Pro Audio Tone Generator

A simple but versatile audio frequency tone generator, capable of precise tone setting to 20kHz. The responsive "knob twiddler" style controls closely emulate similar workbench instruments, while independent left /right channels cater for amplifier testing. Ideal for casual hearing tests, dog training (!), physics lab work (acoustic resonance, beats etc) and perhaps even "give me a C" instrument tuning.

https://play.google.com/store/apps/details?id=com.dutchmatic.patone



GPS Status

GPS Status plus!

Conveniently indicates navigation satellites available, but even with the inbuilt GPS off this still shows a handy compass, spirit level, accelerometer, battery status (plus temperature) and magnetic field measurement.

https://play.google.com/store/apps/details?id=com.eclipsim.gpsstatus2

EMF Meter

EMF meter

Live charts, along with x, y and z components, local magnetic and low frequency EM fields (The earth's magnetic field – measured in tesla – ranges at the surface from 25 to 65 microtesla (= 0.25 to 0.65 gauss or 250-650 milligauss. Handy for ferrous object location, buried live wire detection or even for those concerned with low-frequency electromagnetic radiation in the home.

Note: 10,000 Gauss (G) = 1 Tesla (T). A a strong fridge magnet has a field of about 100G = 0.010T.

https://play.google.com/store/apps/details?id=com.superphunlabs.emf

NOTE: both these apps require the smartphone to have a magnetometer fitted which some smartphones (particularly older models) may not have.

D-I-Y Apps?

App generation usually involves programming skills but Google's open source App Inventor for Android uses a drag and drop graphical interface may ease the pain. MIT have taken over development. Refer https://appinventor.mit.edu/explore/ai2/beginner-videos.html

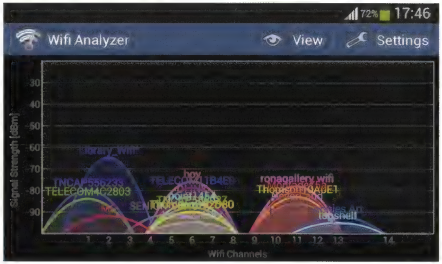
WiFi Analysis

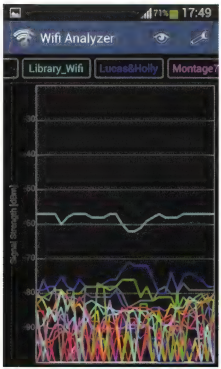
Wifi Analyzer

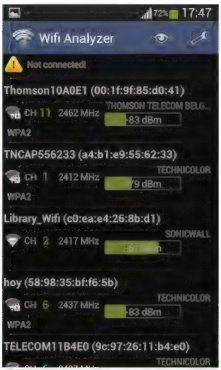
WiFi Analyzer

Due to the user's enveloping hand, smart phone WiFi range is often much less than a more open tablet or laptop will offer. As WiFi access is often free and mobile data costly, this app can be an invaluable aid for sensing the nature and availability of nearby WLANs. Its multiple screens suit signal sweet spot location and even perhaps site auditing for the best positioning of a facility's AP (access point) or antenna for optimum coverage. Highly recommended!

https://play.google.com/store/apps/details?id=com.farproc.wifi.analyzer







Google Sky Map

Google Sky Map

Nothing to do with electronics . . . but perhaps the most magnificent night sky display available. Never confuse Jupiter with Mars again! Once set to your local location and time, it's just held aloft for the live display to inform of the stars and planets above.

https://play.google.com/store/apps/details?id=com.google.android.stardroid

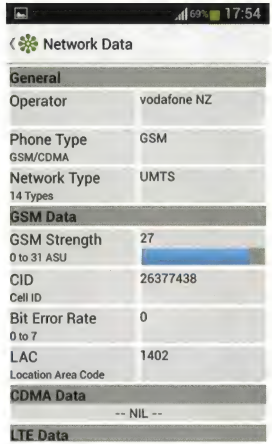
WiFi, Mobile Network Analysis

OpenSignal

OpenSignal

A well respected app for technical insights into both the direction and strength (as -dBm) of nearby cellular signals. Could be particularly useful for locating and mapping the best cellular access location (perhaps elevated) at an unfavourable location. Optionally also detects WiFi signals but the information given is perhaps less helpful that WiFi Analyzer.

https://play.google.com/store/apps/details?id=com.farproc.wifi.analyzer



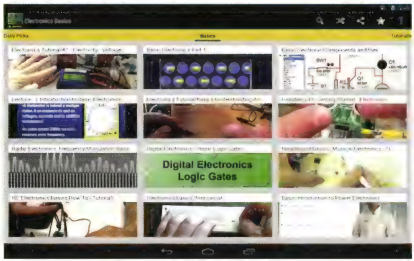
Network Signal Strength

Network Signal Strength

The free version offers simple but perhaps clearer, cellular network insights. GSM strength is shown on a coloured 0-31 scale. Upgrading to the Pro version allows many extra features.

https://play.google.com/store/apps/details?id=com.cls.networkwidget

Useful Electronics Apps



Electronics Basics

Electronics Basics

This app is quite different from most of the apps on line (and those shown in this feature) because the developers don't own any of the content; instead they hand-pick it from a wide variety of different online sources. The result is an app full of electronics tutorial and training videos for you to learn from and enjoy.

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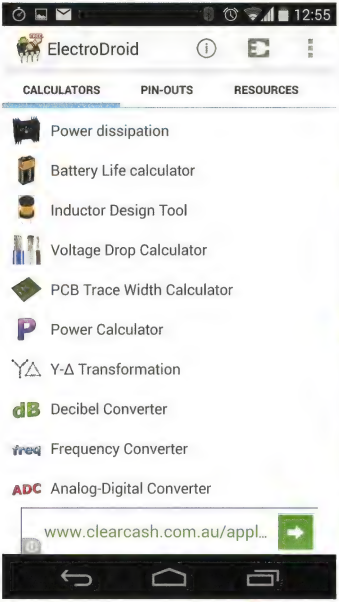
Useful Electronics Apps



ElectroDroid

ElectroDroid

This is an "everything-but-the-kitchen-sink" electronics-orientated app. It includes a bevy of calculators including those for Ohm's law, reactance, resonance, RC filters, voltage dividers, series/parallel components, capacitor charge, op amp circuits, adjustable voltage regulator parameters, NE555 circuits, power dissipation, battery life... the list goes on.

It also has various useful tables such as resistor colour codes, metal resisivity, wire size and current capacity, standard resistor/capacitor values, capacitor marking codes, circuit symbols, SMD package sizes, 7400 series logic IC configurations, ... trust us, there's a lot in it! Not surprising then that this is one of the most popular electronics-related Android apps.

https://play.google.com/store/apps/details?id=it.android.demi.elettronica

EveryCircuitFree

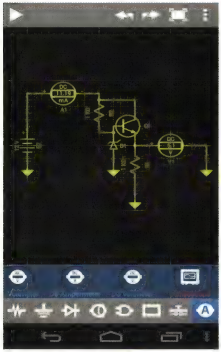
EveryCircuit

Also by the same people as ElectroDroid (and it integrates), this is a very visually-orientated simulator which incorporates many common types of circuits and shows you how they work. It's great for beginners because you can see exactly where the current and voltage are flowing. Shown here is its demonstration of the step response of an RC low-pass filter. The free version can only demonstrate simple circuits; more complex circuits (labelled "Large") require the paid version.

https://play.google.com/store/apps/details?id=com.everycircuit.free

For convenience (and to save you typing them out!), links etc for all apps in this feature can be downloaded from www.manuka.orconhosting.net.nz/apps.htm

Circuit Simulation, Databases and Other Apps

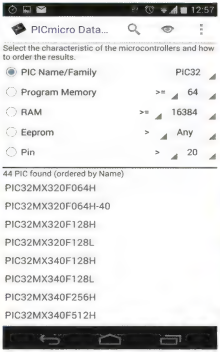


Droid Tesla

Droid Tesla

A "SPICE" circuit simulator with a simple interface. This is a free version; you can pay to get extra features. Drawing the circuit is pretty easy although making connections between components can be a little awkward. Overall, the interface is easy to figure out. Great for checking out those circuit ideas on-the-go to see if they will work.

https://play.google.com/store/apps/details?id=org.vlada.droidtesla



PICmicro Database

PICmicro/ATmicro database

Handy lists of all current Microchip or Atmel microcontrollers which can be sorted and filtered by various parameters such as memory size, number of pins, ADC inputs, package type and so on. Selecting a part gives its vital parameters and a link to the manufacturer website for access to the data sheet, etc. Popular parts also include a pinout diagram.

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Flightradar24 Free

Flight Radar24 Free

Yes, we know we've talked about this one before (see SILICON CHIP, August 2013) but it's so good it's worth including again in case you missed it! You can see, in real time, where every commercial aircraft is at any time, anywhere in the world with this remarkable app. See the plane's height, route, speed, climb, origin and destination and much more!

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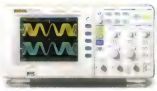

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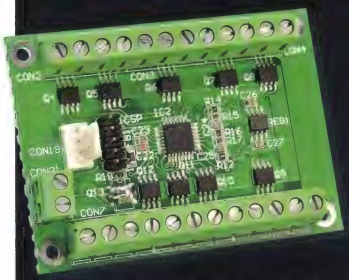
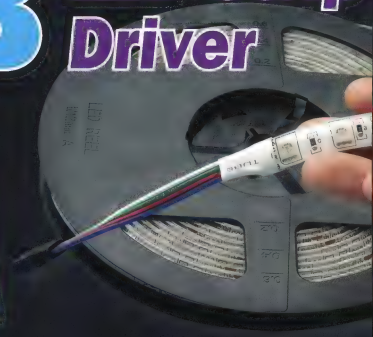
Phantasmagorical RGB LED Strip Driver





This small module drives up to six RGB (red/green/blue) flexible LED strips to produce a rainbow of colours in multiple eye-catching patterns. Use it to decorate a Christmas tree, a shop window or anywhere else you want a bright, pulsating and flashing light show with many colours. It runs off a battery or a DC supply.

THIS PROJECT WAS designed to be used on a float in a street parade. No, this was not an official SILICON CHIP presence . . . It came about because I was helping a friend who was helping a friend to decorate the float and they wanted multiple flexible strings of LEDs, all constantly changing colours.

When I first heard about this, the plan was that they were going to build the electronics by hand, using through-hole components on Veroboard and point-to-point wiring – to drive around 30 RGB strips. I've built many prototypes this way and knew that it was a dull and laborious process and the resulting boards can be quite delicate. So in order to head off the inevitable frustration I offered to design a "proper" PCB.

This was two weeks before the parade so the design and assembly was a pretty quick affair. The boards were designed to be fast to build – I actually had to do them all in one evening after work and managed to assemble the five boards in just four hours and deliver them to be programmed and wired up.

I didn't see them in action but apparently they worked quite well although by the end of the parade the batteries were pretty flat. We hadn't had time to put in a low-battery cut-out feature, something which has been rectified in the final design. Obviously, this board is not limited to use on a float so after some tweaking, we are publishing it for general use.

Design

RGB LED strips can be purchased on 5m reels, made up of 100 joined

By NICHOLAS VINEN

sections each 50mm long. They are also available in shorter lengths. Fig.1 shows a typical arrangement.

These components are mounted on a long, thin flexible PCB with a plastic cover over the top and in our case, with an adhesive backing. Power consumption is around 7.5W/m (375mW per section) at 12V, with all LEDs at full brightness. We measured 920mA for blue, 1150mA for red and 1040mA for green on a 5m strip.

Our reels were supplied with mating 4-pin plugs at either end (2.54mm pin spacing), so they can be combined into longer lengths if required. If you cut the strip up into shorter lengths, this exposes a set of four pads on either side of the cut, to which a similar cable can be soldered. We got ours from an internet seller but very similar products are available from Altronics, Cat. X3213 (indoor) and X3214 (outdoor use). Jaycar also have rigid RGB LED pluggable modules (Cat. ZD0456 and ZD0466) and 1m flexible waterproof RGB LED strip (Cat. ZD0478).

To control these strips to get any colour we want, we apply 12V to the anode terminal and then vary either the resistance or (in this case) PWM duty cycle between the cathodes and ground, to vary the red, green & blue component brightness. These colours combine so, for example, if all three are driven at a similar level, the resulting light looks (more or less) white. Or if red & blue are driven but green is not, the result is mauve.

Now since we drove our strips off a battery, the supply voltage wasn't constant (this will also be true if the power source is unregulated 12V DC from mains). In fact, the Li-Po batteries we used were 4-cell packs with a full charge voltage of 4 x 4.2V = 16.8V and a flat voltage of 4 x 3V = 12V. An unregulated mains-powered 12V DC supply would have a similar voltage range but regulated supplies are more common at the high currents required. A discarded PC power supply would be eminently suitable.

If we simply ignored the varying battery voltage, the LED strips would dim over time as the batteries discharged and we would also risk burning the strips out when the battery is fully charged and the supply is significantly higher than the 12V that the strips are designed to be driven with.

One way to avoid this would be to regulate the supply to a constant 12V but a much easier method is to figure out how the brightness of each colour varies as the supply goes above 12V, then monitor the supply voltage and reduce the duty cycle to compensate, giving constant brightness. This is a very efficient way to do it as very little power is lost and it also minimises the component count.

Since we only need to switch the LED cathodes, this makes the circuit design easy. For each colour of each strip we just need one low-side switch and an N-channel Mosfet does the job. These are available in dual SMD packages which are quite compact and easy to solder, with suitable voltage and current ratings and an on-resistance figure of around 10mΩ. So for each FET handling 1A, the dissipation is only 10mW.

To further simply the circuitry, the Mosfet gates can be driven directly from the outputs of a microcontroller and this is much easier for low-side switching than high-side switching. But we do have to be a little careful

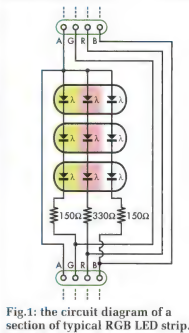


Fig.1: the circuit diagram of a section of typical RGB LED strip. This is repeated every 50mm, with the connectors at top and bottom joined end-to-end. The strip can be cut into any number of whole sections (up to the maximum of 100 supplied on the reel) and can be driven from either end. The more sections you drive, the more current it draws – see text for details.

since microcontroller outputs can provide relatively little current (typically ~40mA DC and 100mA peak) and we also need to make sure we don't exceed the micro's ratings.

The switching time of a micro output driving the small capacitance of the type of Mosfet we're using is quite fast at around 100ns so that isn't really an issue. But when driving 6 x 3 = 18 Mosfets from a single micro, the instantaneous current is a concern should they all switch simultaneously. The micro we're using has an absolute maximum rating of ±40mA (DC) per output pin and 400mA for the whole device.

Examination of the I/O pin source/sink current vs output voltage graphs suggests that the output transistors have an on-resistance of around 100Ω. So if eight outputs are switched simultaneously (the maximum possible with an 8-bit micro) to discharge Mosfet gates at 5V, the total current at that instant would be (5V ÷ 100Ω) x 8 = 400mA. That's just equal to the rating but it's also only for a brief period; as the gates discharge, the sink current

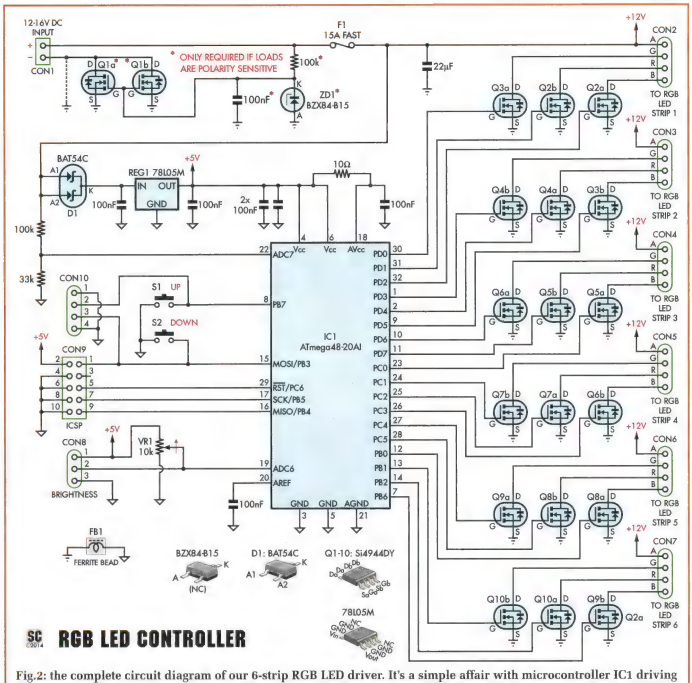


Fig.2: the complete circuit diagram of our 6-strip RGB LED driver. It's a simple affair with microcontroller IC1 driving the gates of 18 Mosfets directly to control the cathodes for three strings of LEDs in each of six connected strips. REG1 derives power for the micro from the nominal 12V supply while S1 & S2 allow the pattern to be changed and VR1 varies the overall LED brightness.

rapidly drops. So we don't see any problems with this arrangement.

Battery protection

We also need to consider the health of the battery. A lead-acid battery could be used and these can be discharged to about 11.5V before being damaged, but by then the battery will be well and truly flat and the LED strips will be noticeably dimmer.

Li-Po batteries should not be discharged below about 3V per cell, ie, 12V for a 4-cell pack, or else they can be destroyed. So to be safe, the unit should stop drawing current once the battery voltage drops much below 12V.

We're already monitoring the supply to provide LED PWM duty cycle compensation, so it's simply a matter of the programming the micro to turn off all the outputs and go to sleep if the battery voltage drops too low. It can then periodically wake up to check the voltage and if it recovers sufficiently (eg, the battery is under charge), it can then go back to normal operation.

In sleep mode, the only part of the circuit drawing any significant current is the 78L05M regulator at about 3mA. With the large battery required for this project, that will give you several days to disconnect the unit and recharge the battery before it goes totally flat. This time could be extended dramatically by replacing the regulator with a lower

Parts List

1 double-sided PCB coded 16105141, 82 x 55mm
1-6 RGB LEDs or LED strips
1 12V DC power supply or 12V battery
13 2-way PCB-mount terminal blocks, 5.08mm spacing, rated at 15A+ (CON1-CON7) (eg, Dinkle EK [Altronics P2032A], Weidmuller PM [Jaycar HM3130])
1 15A SMD fuse, 3216 or 6432 size (1206/2512 imperial) (F1) (element14 2135886, Digi-Key 507-1059-1-ND)**
1 mini horizontal 10kΩ trimpot (VR1) (optional) OR
1 3-pin header (CON8) plus external pot & wiring (optional)
1 5 x 2 pin header (CON9) (not required with pre-programmed microcontroller)
2 PCB-mount tactile buttons (S1,S2) OR
1 4-way pin header (CON10) plus external buttons & wiring
1 SMD ferrite bead, 3216 size (1206 imperial) (element14, RS, Digi-Key)

Semiconductors

1 Atmel ATmega48-20AI or -20AU 8-bit 4KB microcontroller programmed with 1610514A.HEX (IC1) (element14 Cat 9171312, Digi-Key ATMEGA48-20AU-ND)
1 78L05M SMD 5V 100mA regulator (REG1) (Jaycar ZV1540)*
9 Si4944DY SMD dual N-channel Mosfets or equivalent (Q2-Q10) (Jaycar ZK8821)*
1 BAT54C dual common-cathode Schottky diode (D1)*

Capacitors

1 22µF 25V SMD ceramic, 3216 size (1206 imperial) (element14 2354129, Digi-Key 1276-3047-1-ND)
7 100nF 50V SMD ceramic, X7R, 1608 or 2012 size (0603/0805 imperial) (element14 1301790/1301894, Digi-Key 1276-1180-1-ND/311-1344-1-ND)

Resistors (all SMD 1608 or 2012 size [0603/0805 imperial])

1 100kΩ* 1% 1 10Ω*
1 33kΩ* 1%

* These parts are available from element14, RS, Digi-Key and Mouser and can be found by part code or parameter search
** Spare SMD fuses wouldn't go astray

quiescent current type but in most cases this should not be necessary (the micro draws <1µA in sleep mode).

Circuit description

Fig.2 shows the full circuit. The LED strips are wired to 4-way terminal blocks CON2-CON7 and Mosfets Q2a-Q10b switch the cathodes, with the anodes all connected together to the (nominal) 12V supply. This supply comes via input connector CON1 and passes through a 15A PCB-mount SMD fuse, which we put in as last-ditch protection against a serious fault such as a shorted output (Li-Po batteries don't like to be shorted out). A 22µF capacitor smooths this supply and reduces its impedance.

The micro we've used is an ATmega48 in a 44-pin SMD package. We chose this because it's easy to program and as described above, has good output drive capability for switching the Mosfet gates. Its 5V supply is derived from the fused 12V rail via reverse polarity protection Schottky diode D1 and REG1. D1's two internal diodes are paralleled for lower losses and higher current capability.

The micro has a 100nF bypass capacitor for each of its V_{CC}/AV_{CC} (analog supply) inputs. AV_{CC} is smoothed by a low-pass filter formed by a 10Ω resistor in combination with its 100nF bypass capacitor.

The 12V supply is monitored using a 100kΩ/33kΩ resistive divider from that rail to ADC input 7 (pin 22). This 4:1 divider gives a voltage at pin 22 of 2.875-4.25V (11.5-17V supply) which is measured relative to the 5V rail. A 100nF capacitor from the A_{REF} pin (pin 20) to ground filters switching noise from the reference voltage which is derived from AV_{CC}.

The microcontroller can be programmed via a standard 10-pin Atmel AVR in-circuit serial programming (ICSP) header (CON9). However, we can supply pre-programmed micros in which case CON9 can be omitted.

The original design had a fixed LED display pattern but we decided to revise it to give multiple patterns, hence the addition of pushbutton switches S1 and S2. These are connected to input pins PB3 and PB7 of IC1 which have internal pull-ups enabled. S2 shares a line with the programming header, which is fine as long as you don't press it during programming.

CON10 allows off-board buttons to be used instead of S1/S2 if desired. Trimpot VR1 gives overall LED brightness control or an off-board pot can be wired to CON8 which is fitted in place of VR1. You can also simply solder a wire link between pins 1 and 2 of CON8 so that the LEDs run at full brightness all the time.

The ground connection for switching Mosfets Q2-Q10 is kept separate from the ground for the rest of the circuit, hence the use of two different symbols. These two grounds are joined at a single point by ferrite bead FB1, which reduces the coupling of switching noise into the microcontroller's ground, thus reducing errors in its ADC readings.

FB1 is shown in the botton lefthand corner of the circuit, connecting the Mosfet ground to the input supply ground.

Finally, note that we show components to protect the load from reversed polarity on the input connector. These are Q1, ZD1 and a 100nF capacitor and 100kΩ resistor. However, the LED strips are unlikely to be damaged by reverse polarity so they probably do not need to be installed; **a track on the board (shown dashed) connects the ground return directly to CON1 and must be cut if Q1 is to be fitted.**

We've left provision for these components on the PCB, in case a different type of load is connected which is polarity sensitive.

Note that fuse F1 is a surface-mounting component and if it blows you will have to de-solder it and solder another in its place. However, with some care in wiring the unit up and ensuring that it's used within its ratings, there's no reason for it to blow. If you aren't planning to use the full

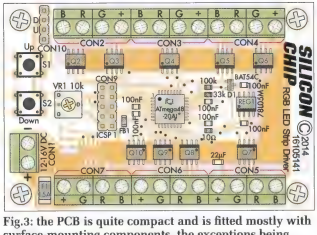
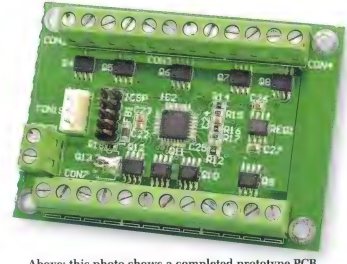


Fig.3: the PCB is quite compact and is fitted mostly with surface-mounting components, the exceptions being the connectors, pushbuttons S1 & S2 and trimpot VR1. S1, S2 & VR1 can also be mounted off-board to give external controls or left out entirely if their functions are not needed (VR1 must be linked out in this case).



Above: this photo shows a completed prototype PCB assembly. Note that the final version shown in Fig.3 has a few changes, including the addition of trimpot VR1, pushbutton switches S1 & S2 and SMD fuse F1.

current capabilities of the device, eg, your load will never exceed 10A, it's a good idea to fit a fuse with a lower rating (but higher than the expected maximum load current). You could also use an inline fuse from the battery which would be easier to replace.

Software

Since this chip only has a handful of PWM channels, we have to use the outputs as general purpose I/Os and arrange the software to provide PWM by constantly updating these output states. They have been arranged to make it simple for the software by wiring up the Mosfet gates to sequentially numbered pins.

The micro runs at 8MHz with one of its internal timers configured to divide-by-128 to give 62.5kHz. It then divides this by 256 brightness levels to get 244Hz PWM operation. The main loop continuously calculates the next state of each output as an RGB value from 0-255 (ie, from off to maximum brightness) and then computes the timing for switching the Mosfets off and on to achieve this. The timer interrupt is then set to trigger a subroutine at the right times to turn the outputs on and off to achieve this pattern.

This repeats indefinitely. It periodically stops to check the position of VR1 and whether S1 and/or S2 have been pressed. If so, it switches patterns.

PCB assembly

The PCB assembly is relatively straightforward with no particularly difficult-to-solder parts but some care does need to be taken to ensure the SMD solder joints are properly formed and there are no bridges. Start with the SMD ICs and Mosfets, then follow with the passive SMDs and finish up with the through-hole parts.

IC1 is probably the best one to do first. This is installed by positioning it on the board with the correct orientation, placing some solder on one of its pads and heating that pad while sliding the IC into place. You should then check its alignment. Make sure all the pins are properly centred on the pads and then solder the diagonally opposite pin. Make a final check that the orientation is correct, then solder the rest of the pins.

It's possible to solder each of IC1's pins individually with a fine-tipped soldering iron but it is not necessary to do so. You can place the tip of the iron between a pair of pins and flow solder onto both, then clean it up later using solder wick. You could also use a mini-wave/hoof tip or one of various other methods such as hot-air or oven reflow.

It's a good idea to use flux paste, both to aid the initial soldering and in combination with solder wick if cleaning up any bridges is necessary. When finished, clean off any flux residue with a good solvent (we mentioned some in our article on soldering last month), then inspect the joints carefully under a magnifying glass with good illumination. Check that they have all formed good fillets between the IC pins and the PCB.

Next, you can then proceed with fitting Mosfets Q2-Q10 and regulator REG1. Pay close attention to the pin 1 marking which may be a dot or bevelled edge and make sure the 78L05M goes in the right place. The pin spacing on these parts is larger than IC1 so it's realistic to solder the pins individually although the techniques mentioned above remain valid. As with IC1, a careful inspection of the joints is most important.

Now fit D1 using a similar approach; you certainly can solder its pins individually. Then follow with the passives (resistors & capacitors) but remember to wait a few seconds after sliding the part into position before soldering the opposite side so that the first joint has had time to cool.

One way to check whether these components have been soldered properly is to heat one end and apply gentle pressure on the part with the soldering iron; if the opposite joint is bad, it will slide out of position and you will have to remove it and re-solder it.

Assuming that the joint is OK, let it cool and then check the other using a similar method. However, after doing this you should inspect the joints and re-flow them if they look crystalline or lumpy.

Solder fuse F1 in place, then move on to the through-hole parts, starting with S1 & S2 or alternatively CON10 which is wired up to external buttons later. Or you could leave these parts

off altogether and the unit will then be permanently set to pattern cycle mode.

Before fitting the terminal blocks, gang them up into two sets of six, using the integral slots and tabs. That done, make sure they are pushed down fully onto the PCB with their wire entry holes facing outwards before soldering all the pins. Then fit either VR1, a 3-pin header in its place or a wire link between the two lower pads. Finish off by soldering CON9 but note that it isn't necessary if you're using a pre-programmed microcontroller.

Features & Specifications

Outputs: 6 x 3-channel 12V RGB LED strip drivers (common anode), up to 5A each strip (15A total maximum)

Input: 12-17V DC at up to 15A from battery (lead-acid, Li-Ion, Li-Po) or mains supply.

Patterns: 10 different patterns plus auto-cycle mode which changes pattern periodically.

Protection: fuse, reverse polarity protection, battery over-discharge protection.

Other features: constant brightness, optional brightness control.

Battery cut-out: ~11.5V with 0.5V hysteresis.

PWM frequency: ~250Hz.

Programming

If using a blank micro, now is a good time to program it. First, connect a 12V supply (current-limited, if possible) to CON1 and check that there is 5V between pins 2 & 4 of CON9. You can then connect an AVR ICSP tool and upload the HEX file, which can be downloaded from the Silicon Chip website (free of charge for subscribers).

You will also need to set the 'fuse bits'. An unfortunate aspect of programming AVRs is that these are not included in the HEX file and there is no consistent way of referring to them. There are two bytes to set. Set the fuse high byte to 'DC' hex and the fuse low byte to 'C2' hex.

Depending on your programmer, you may not be able to set these as hex values so instead, for the high byte, set BODLEVEL to '100' (4.3V) and leave the rest of the settings at their defaults, ie, RSTDISBL = 1 (off), DWEN = 1 (off), SPIEN = 0 (on), WDTON = 1 (off) and EESAVE = 1 (off).

For the low byte, set CKSEL = 0010 (Calibrated Internal Oscillator), with CKDIV8 = 1 (off) and SUT = 00 (fast rising power). Leave CKOUT at its default value, ie, CKOUT = 1 (off). This sets the chip to operate at 8MHz, as expected by the software.

Testing

There isn't much to test; check that the 5V supply is correct as described above and that the current draw is reasonable (<30mA), then connect a proper 12V supply and a LED strip to one of the outputs and power it back up. You should see the LEDs light up and the colour change over time. If so, you can then switch off and connect strips to the remaining outputs, switch back on and check that they are all operating and displaying the full range of colours.

Press S1 & S2 to see that the pattern changes and if VR1 is fitted, adjust it and check that it controls the brightness. Note that if you are using an off-board pot, this will need to be wired up for testing or else the results will be unpredictable (but no damage should occur).

Using it

Pressing S1 cycles to the next pattern and pressing S2 switches to the previous pattern. Initially, the unit starts with pattern 1, then after a minute or so switches to pattern 2 and eventually after pattern 10, it goes back to the first one. This cycle repeats 'forever' but it is cancelled by pressing either S1 or S2 after which it will remain on that same pattern. To switch back to auto-cycling mode, press S1 & S2 simultaneously.

VR1 adjusts the maximum duty cycle but note that the duty cycle is also automatically reduced as the supply voltage rises above 12V to give even brightness regardless of battery voltage (down to a minimum 12V). Note also that should the battery voltage drop below about 11.5V (including wiring drops), the unit will shut down until it rises above 12V or so. SC

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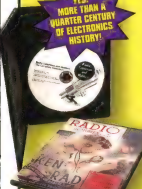

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Introducing the Micromite, Pt.1

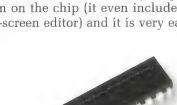
By GEOFF GRAHAM

. . . an easily programmed powerful microcontroller

Want a powerful microcontroller in your next custom project but you are concerned about how to program it? Behold the Micromite! It's a low-cost 28-pin PIC32 microcontroller which comes loaded with a Microsoft-compatible BASIC interpreter with all the features you need. And programming with MMBasic is dead easy. This month we describe its features, show how to drive it and how to use it to build a GPS-Controlled Digital Clock.

BELIEVE US! Even if you've never programmed a micro before, now you can do it! If you thought PICAXE was good, just check out the Micromite!

MMBasic has all the power that you need including a huge amount of memory, floating point numbers, string handling, arrays, 19 I/O pins, two serial ports, I²C, SPI, 1-Wire and PWM. You can write, test and save your program on the chip (it even includes a full-screen editor) and it is very easy to get something up and running.



This low-cost 28-pin PIC32 chip includes a full-featured BASIC interpreter with the capability of driving 19 I/O pins, two serial ports, I²C, SPI, 1-Wire and PWM. It can also handle up to five servos, infrared remote control, distance sensors, temperature sensors and much more.

When you have finished, you can lock down the chip and it will automatically run your program at start up.

For people who remember our Maximite series of computers, we are using the same Microsoft-compatible BASIC programming language but it's now running inside a cheap 28-pin IC. The result is not quite a Maximite . . . but it's close. Instead of using a keyboard, video & USB, it uses serial I/O for the console and instead of using an SD card, it stores its program in internal flash memory.

Other than that, the Micromite runs the same full MMBasic with all its high level features including easy control of its I/O pins, powerful mathematics and a full range of communications protocols.

It has extra features such as being able to: (1) change the processor's clock speed (to reduce power consumption), (2) put the chip to sleep (80μA sleep current) and (3) set a password to prevent someone from listing/changing the program, etc.

As far as performance is concerned, it's no slouch. Our benchmark clocks it at 21,748 lines/second (the Colour Maximite does 27,340) and it has a total of 42KB memory for the program plus variables (the Colour Maximite has 31KB). Everthing happens inside the chip; the only extra component needed is a 47μF capacitor.

The power supply requirements are tiny. The Micromite is powered from a 2.3V-3.6V rail and consumes between 4mA and 25mA, depending on the clock speed selected. This can be provided by a couple of 1.5V AA cells or a simple power supply.

Where's the PCB?

Readers familiar with the Maximite might ask "where's the PCB with a display, I/O connectors, etc?" There is none! What? How can that be?

The answer is to not think of the Micromite as a computer but as a programmable microcontroller which you build into a circuit and program in place. If you want to experiment with the chip, you can plug it into a solderless breadboard as shown on the opposite page. Once you have the hang of how it works, you then design a circuit around it and develop your program while it is in the circuit.

This "in circuit development" is

very productive as it allows you to develop and test small parts of the program as you go. For example, if your project was a home-brew controller, you could develop and test the temperature sensor first, then the power control and so on. The final program would just string these modules together.

Quick demonstration

For a lot of people, microcontrollers are a mysterious technology. If you buy one and simply connect it into a circuit, it will do nothing. That's because you must first write and install a software program for it. That usually involves installing the required compiler, linker and other software on a desktop computer, then learning a complex programming language such as C or Assembler.

As a result, most people's experience with microcontrollers simply consists of buying a pre-programmed chip as part of a kit. But then you cannot change what it does to suit your preferences, since all the instructions are encoded in a cryptic hex file; unless, that is, you have the original source code, a compiler and a programmer to reflash the firmware. You also need to understand the language used for the source code to make any modifications.

The Micromite is completely different and we will now show you how it's programmed by quickly demonstrating how to flash a LED on and off.

To begin, the Micromite is programmed via a serial terminal. You have many choices here and we will go into these later. Once it's connected, you will be presented with the Micromite's command prompt (a greater than symbol, ie '>').

At this point you can enter the command **EDIT** and the Micromite's full screen editor will start up. Fig.1 shows the editor in action with the LED flashing program already entered.

The first line of the program configures an output pin (pin 15 in this case) as a digital output (DOUT). The program then enters a continuous loop where the output is repeatedly set high and then set low again, with a pause of 250ms between each state. This is as simple as it gets and is all that that is needed to make a LED cycle on and off.

When you exit the editor the program will be automatically saved to the Micromite's internal flash memory which is non-volatile. This means that you will never lose your work, even if you remove the power.

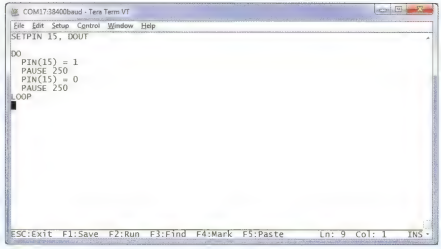
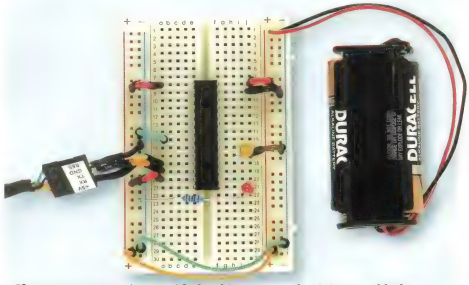


Fig.1: the inbuilt editor is very useful as it allows you to edit, save and run your programs directly on the Micromite. You don't need a host computer, compiler or other special software (other than a terminal emulator).



If you want to experiment with the chip you can plug it into a solderless breadboard. Then, once you have the hang of how the chip works, you can design a circuit around it and develop your program while it is in circuit. This test set-up is running the flashing LED program shown in Fig.1.

If you now type **RUN** at the command prompt, the program will run, flashing the LED on and off. It's a very simple program but it does illustrate how the Micromite can interface to external circuitry.

You now have the Micromite doing something useful (if you can call flashing a LED useful). If that's all you want it to do, you can then instruct MMBasic to always run this program whenever power is applied. That's done by entering the command **OPTION AUTORUN ON** at the command prompt.

To test this, simply remove the power and then reapply it again. The Micromite should immediately begin flashing the LED.

If you now disconnect the serial console, it will sit there flashing the LED forever (well, for as long as the battery lasts). And if you ever need to change something (for example, to flash a second LED), it's just a matter of re-attaching your serial terminal to the Micromite while it's still in circuit and editing the program as required.

That's the great benefit of the Micromite – it's very easy to write and change a program.

Microcontroller

The Micromite is essentially a Micro-

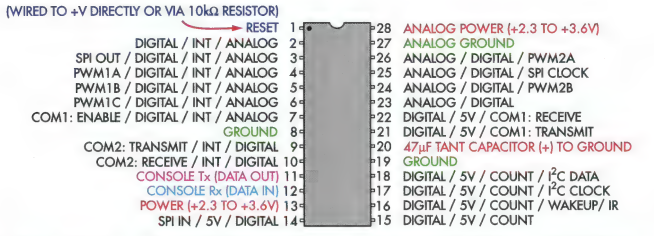


Fig.2: these are the pin connections for the Micromite while below are the functions that each pin can be used for. The pins marked with colour labels are used for power and serial data communications, etc and cannot be used for general I/O. The other pins can be used for the following functions:

- **ANALOG: these pins can be used to measure voltage (AIN).**
- **DIGITAL: can be used for digital I/O such as digital input (DIN), digital output (DOUT) and open collector output (OOUT).**
- **INT: can be used to generate an interrupt (INTH, INTL and INTB).**
- **COUNT: can be used to measure frequency (FIN), period (PIN) or counting (CIN).**
- **5V: these pins can be connected to 5V circuits. All other I/O pins are strictly 3.3V maximum.**
- **COM xxx: used for serial communications.**
- **I²C xxx: used for I²C communications.**
- **SPI xxx: if SPI is enabled, these pins can be used for SPI I/O**
- **PWM xxx: PWM or SERVO output (see the PWM and SERVO commands)**
- **IR: can be used to receive signals from an infrared remote control (see the IR command)**
- **WAKEUP: can be used to wake the CPU from a sleep (see the CPU SLEEP command).**

Note: the mnemonics in brackets are the modes used in the SETPIN command.

chip PIC32MX150F128 microcontroller programmed with the MMBasic firmware (available on the SILICON CHIP website, along with the Micromite User Manual). Blank chips can be purchased for $3-$4 from element14, RS Components, Digi-Key etc or direct from Microchip. You will also need a programmer such as the PICkit3 to install the MMBasic firmware.

An easier option is to purchase a pre-programmed chip from the SILICON CHIP Online Shop for $15 (plus postage) and we will even throw in the 47µF capacitor that you need.

A panel later in this article lists the chips that you can use. Essentially, they are available with two frequency ratings (40MHz and 50MHz) and in a variety of package styles.

When the Micromite starts up, its clock frequency will be set at 40MHz but this can be changed to 48MHz under program control. We have tested a number of 40MHz chips at 48MHz and they worked fine, so the decision as to exactly which chip you want to use is up to you. The chip that's supplied pre-programmed from the SILICON CHIP Online Shop is rated at 50MHz and has 19 I/O pins (see below).

You can also use the PIC32MX25-0F128 series of chips from Microchip. These have two pins dedicated to a USB controller (which is not used in the Micromite) so these chips only have 17 I/O pins available to your BASIC program. MMBasic will also run on the 44-pin surface-mount chips in the PIC32MX150F128 range and these give you a 33 I/O pins to play with. We'll have more to say about this chip in a follow-up article.

I/O pins

Fig.2 shows the pin-outs of the Micromite and the capabilities of each I/O pin. It would be worth copying and laminating this diagram as you will find yourself referring to it often when designing with this microcontroller.

In MMBasic, the pin numbers are the same as the physical pin numbers on the chip. So, for example, **PIN(15) = 1** will set the physical pin 15 on the chip high.

Nine of the 28 pins are dedicated to functions such as power and ground so that leaves 19 pins that you can use in your program. All the I/O pins can be set as digital inputs or outputs. An input uses TTL voltage levels, has a high input impedance (typically 1MΩ) and a Schmitt trigger buffer which ensures a clean transition from high to low. The pins that are marked '5V' can be connected to a 0-5V source, while the remainder are limited to 3.3V maximum.

When used as digital outputs each I/O pin can source or sink about 10mA. This can be used to directly drive a LED via a resistor (typically 82Ω) or a transistor which can in turn control a relay and some other high-powered device.

Ten of the pins can also be set to analog inputs. In this mode, the input is returned as a floating point number representing the voltage on the pin. For example, when measuring an alkaline

cell, the reading might be 1.246.

The four pins marked COUNT can be used for measuring frequency (up to 400kHz), measuring the period between input pulses or simply as a counter counting the number of pulses on the input over time.

If by now you are fretting about remembering and using all these functions, the Micromite firmware download on the SILICON CHIP website includes a comprehensive user's manual (over 63 pages). We will also explore the above features and more in detail next month.

Specialised functions

Many of the pins on the Micromite are also used for more specialised functions. For example, the pins marked COM1 and COM2 can be used for serial communications.

COM1 is especially versatile; it can run at up to 230,400 baud and will support RS-232 signals without a transceiver, as well as 9-bit transfers with RS-485 support.

Pins 3, 14 & 25 can be used for SPI (Serial Peripheral Interface) communications which can run at up to 10MHz, while pins 17 & 18 support the I^2C protocol at speeds up to 400kHz as either a master or a slave. In addition, any I/O pin can be used for 1-Wire communications and MMBasic even includes a special function to conveniently get the reading from a DS18B29 temperature sensor chip. In practice, multiple temperature sensors can be used and this makes the Micromite ideal for temperature control and monitoring.

There are five pins marked PWM and these can generate a pulse width modulated (PWM) signal of between 20Hz and 500kHz. This feature lets you control devices that require an analog input voltage, such as motor speed controllers or test equipment. This function is also useful for dimming the backlight of LCD modules under program control.

Each PWM output can also control a servo using the **SERVO** command, so you can control up to five such devices.

The IR function pin (pin 16) can be used to receive signals from an infrared remote control. This will work with any Sony-compatible remote control and MMBasic will do all the work for you in decoding the signal and handling features such as automatic repeat. This allows your Micromite-based project to be remotely controlled with just a few lines of BASIC.

You can also generate IR commands from within MMBasic, so that one Micromite could control another via infrared using an appropriate IR LED.

Micromite Specifications

Power Supply

Supply Voltage:	2.3-3.6V (3.3V nominal) @ 5-25mA; 4V absolute maximum
Current at 48MHz:	26mA typical (plus current from the I/O pins).
Current at 5MHz:	5mA typical (plus current from the I/O pins).
Sleep current:	80µA typical (plus current from the I/O pins).

Digital Inputs

Logic Low:	0-0.65V
Logic High:	2.5-3.3V on normal pins; 2.5-5.5V on pins rated at 5V
Input Impedance:	>1MΩ. All digital inputs are Schmitt trigger buffered
Freq. Response:	up to 200kHz (pulse width 20ns or more) on the counting inputs (pins 15-18).

Analog Inputs

Voltage Range:	0-3.3V
Accuracy:	analog measurements are referenced to the supply voltage on pin 28 and the ground on pin 27. If the supply voltage is precisely 3.3V, the typical accuracy will be ±1%.
Input Impedance:	>1MΩ (for accurate readings, the source impedance should be <10kΩ)

Digital Outputs

Current draw or sink: 10mA (absolute maximum 15mA per pin or 200mA for the whole chip)
Maximum Open Collector Voltage: 5.5V

PWM Output

Frequency range:	20Hz to 500kHz
Duty cycle:	0-100% with 0.1% resolution below 25kHz

Communications Speeds

Console Serial:	default = 38,400 baud; range = 100bps to 230,400bps (at 40MHz)
COM1 Serial:	default = 9600 baud; range = 10bps to 230,400bps (at 40MHz)
COM2 Serial:	default = 9600 baud; range = 10bps to 19,200bps (at 40MHz)
SPI:	10Hz to 10MHz (@ 40MHz clock speed); limited to one quarter of the clock speed
I^2C:	10-400kHz
1-Wire:	fixed at 15kHz

Timing Accuracy

All timing functions (the timer, tick interrupts, PWM frequency, baud rate, etc) dependent on the internal fast RC oscillator which has a specified tolerance of ±0.9% but typically is within ±0.1% at 24°C.

Flash Endurance

Over 20,000 erase/write cycles. Every program save incurs one erase/write cycle. In a normal program development it is highly unlikely that more than a few hundred program saves would be required.

Driving an LCD module

Another handy feature built into MMBasic is the ability to directly control low-cost LCD modules with one, two or four display lines. By using just one program instruction, you can display whatever data you would like on these modules.

An associated feature is the ability to connect a 4 x 3 or 4 x 4 keypad and easily read the key presses using your BASIC program. This, along with the LCD driver, makes it easy to build things like burglar alarms, reticulation controllers, home-brew controllers and more, all based on the Micromite. We will describe these features in greater detail next month and give some example circuits.

Loading the firmware

As mentioned earlier, you can purchase a Micromite chip pre-programmed with MMBasic from the SILICON CHIP shop. That's the easy

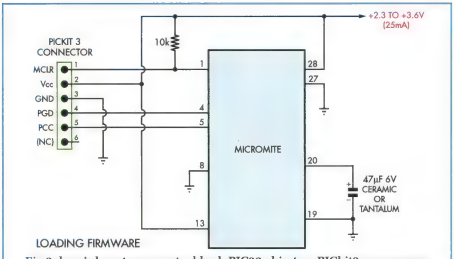


Fig.3: here's how to connect a blank PIC32 chip to a PICkit3 programmer to load the MMBasic firmware. Once connected, you use MPLAB IPE (free from Microchip) to program the device.

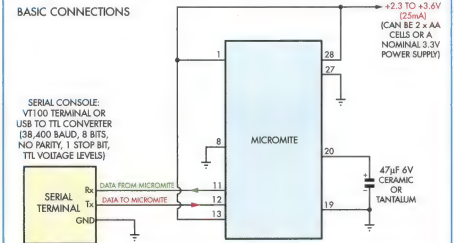


Fig.4: follow this diagram to connect the Micromite to a serial terminal. The easiest option is to use a USB-to-serial converter (eg, Jaycar Cat. XC4241) or the USB-To-RS232C Serial Interface described last month.

option but you could also purchase a virgin chip (ie, blank) and load the firmware yourself.

That's done using a programmer such as the Microchip PICkit3. These are reasonably cheap and there are clones on eBay that are even cheaper. If you install the free Microchip MPLAB X development environment on your computer, you will find that it includes the MPLAB IPE which is an independent programmer that knows how to drive the PICkit3.

You connect the PICkit3 to the blank PIC32 chip as shown in Fig.3. It's then just a matter of instructing MPLAB IPE to program the device after which you can disconnect the programmer as it will not be needed again (unless you wish to later re-program the chip with an updated version of the firmware).

Note that unlike the Maximite, the Micromite doesn't have the ability to update its firmware itself. So you will need the PICkit3 if an MMBasic update is released and you wish to upgrade. That said, we made a considerable effort to remove any bugs and the firmware has been checked by a team of over 40 beta testers for a couple of months, so we believe that the need for this will be unlikely.

Connecting it

Once you have the chip running MMBasic, you can connect it into a circuit. A solderless breadboard makes it easy to experiment. With this set-up, you can program and test the Micromite chip with external devices such as LEDs, button switches and sensors.

Fig.4 shows the basic terminal connection diagram. As previously stated, the power supply voltage can range from 2.3-3.6V (3.3V recommended) and can come from a couple of 1.5V AA cells or a conventional supply. The Micromite's current drain is modest (25mA maximum plus the current drawn by any external LEDs, etc), so a simple power supply would be fine.

Generally, it's good design practice to install a 100nF bypass capacitor close to each of the power supply pins but this is not critical and they are not shown in this diagram.

The capacitor connected to pin 20 is essential and is used to stabilise the internal 1.8V regulator that powers the chip's CPU. It must be a high-quality capacitor (not an electrolytic) and should have a minimum value of 10µF with an ESR (equivalent series resistance) of less than 1Ω. The recommended type is either a 47µF tantalum or a 10µF multilayer ceramic.

Console connection

You also need to connect a serial terminal to the pins reserved for the console. The console defaults to 38,400 baud, eight bits, no parity and one stop bit. The voltage levels are TTL which means that idle is voltage high (3.3V), the start bit is voltage low, data logic 1 is voltage high and the stop bit is voltage high.

This is standard in the microcontroller world so you will not have any trouble finding something to connect to it. Probably the easiest option is to use one of the many USB-to-serial converters available such as Cat.XC4241 from Jaycar **(its output switch should be set for 3.3V operation).** If you look on the internet, you will find thousands more with prices as low as $5.

The USB-To-RS232C Serial Interface described in the April 2014 issue of SILICON CHIP could also be used. **However, since its output swing is 5V and the Micromite's serial interface can only handle 3.3V, you need to install a 1kΩ resistor in series with pin 12.** In fact, this is a good idea regardless, as it will protect the chip in case you hook up a RS-232 port or other serial adaptor that works above 3,3V.

These converters plug into a spare USB port on your computer and at the other end provide a TTL level serial output which can be directly connected to the console input/output pins of the Micromite.

Another option is the SILICON CHIP

ASCII Video Terminal which we will describe in a following article. As well as containing a USB-to-serial converter, this cheap gadget will also take an input from a standard PS/2 keyboard and output either composite or VGA video on a suitable monitor. This means that you can develop and run your Micromite programs without a host computer.

You may be tempted to directly connect an RS-232 serial device, such as a PC's serial port, directly to the Micromite's console pins. **Don't do this, as RS-232 uses ±12V for signalling and you could easily damage your Micromite.** If you do want to connect an RS-232 device to the console pins, you must use a converter.

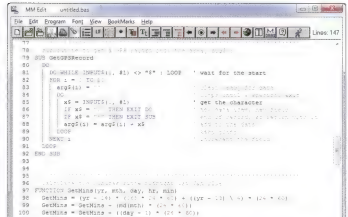
ASCII serial terminal

Now that you are connected you need a terminal emulator running on your computer. This is a piece of software that emulates an ASCII serial terminal. Anything typed on your computer's keyboard will be sent to the Micromite via the USB-to-serial converter and any output from the Micromite will be displayed on your computer's screen.

It's important that your terminal program emulates a VT100 terminal as the program editor built into the Micromite uses that scheme to control the cursor and to display things like reverse video. For Windows, **Tera Term** is the best choice and the Micromite has been extensively tested with it.

This is a typical USB-to-TTL serial converter that you can use with the Micromite. The serial interface is connected to the Micromite's console pins, while the USB interface goes to a standard PC. You can use a terminal emulator such as Tera Term to connect to the Micromite and edit/run your programs. A converter like this can also be used with MMEDIT which gives you much better editing facilities.

Fig.5: MMEDIT was written by Jim Hiley and can be installed on a Windows or Linux PC. It allows you to edit your program on the PC and then, with a single mouse click, transfer it to the Micromite for testing.



When installed with the correct drivers, the USB-to-serial converter appears as a serial COM device on your PC, eg, as COM17. In the Tera Term set-up menu, you should select the COM number and set the other items to 38,400 baud, eight bits, no parity and one stop bit.

If you don't know the COM number for your USB-to-serial converter, you can check this in Device Manager (under Serial Ports). Alternatively, you can select each port found by Tera Term in turn and test it by pressing return (ie, a trial and error process). When you find the Micromite (ie, the correct port is selected), you will be greeted by the command prompt (ie, >).

If you are using the ASCII Video Terminal (described in a future issue), it's even easier – just connect a keyboard and a monitor and set the jumpers to a baud rate of 38,400. You don't need a terminal emulator as the ASCII Video Terminal emulates a VT100 terminal, so you can edit your programs on the Micromite using only this device.

In fact, the Micromite and the ASCII Video Terminal together provide most of the facilities of the original Maximite in two 28-pin DIP ICs.

Program editor

As stated, the built in editor is very useful as it allows you to edit, save and run your programs on the Micromite. You don't need a host computer, compiler or other special software (other than a terminal emulator). Fig.1 shows what the editor looks like.

The editor is invoked with the **EDIT** command. The cursor will be automatically positioned where you left off editing or, if your program has just been stopped by an error, will be positioned at the line that caused the error.

If you are used to an editor like Notepad, you will find that the operation of this editor is familiar. The arrow keys will move your cursor around in the text, while home and end will take you to the beginning or end of the line. Page up and page down will do what their titles suggest, the delete key will delete the character at the cursor, and backspace will delete the character before the cursor. The insert key toggles between insert and over-type modes.

About the only unusual key combination is that two home key presses will take you to the start of the program and two end key presses will take you to the end.

At the bottom of the screen, the status line will list the various function keys used by the editor and their action. These include save (F1), save and run (F2), find (F3), etc. The editor also includes the facility for marking text which can be copied or cut to the clipboard and inserted elsewhere.

By using this editor, you can write your program and then save and run it directly on the Micromite by pressing the F2 key. If the program stops with an error, pressing function key F4 will run the editor again with the cursor positioned at the line that caused the error. This edit/run/edit cycle is very fast.

MMEDIT

Another convenient method of creating and testing your programs is to use "MMEDIT" (see Fig.5). This program was written by SILICON CHIP reader Jim Hiley from Tasmania. It can be installed on a Windows or Linux computer and it allows you to edit your program on your PC then, with a single button

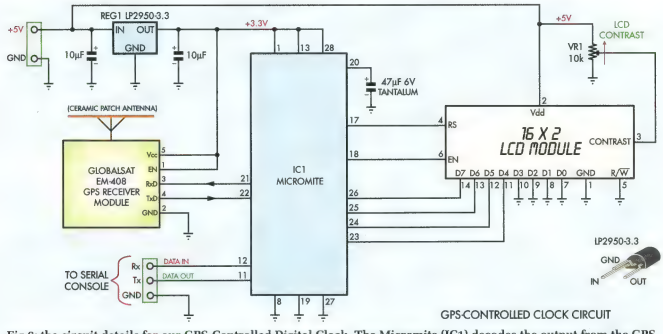


Fig.6: the circuit details for our GPS-Controlled Digital Clock. The Micromite (IC1) decodes the output from the GPS module, calculates the time zone offset and daylight saving adjustment and drives a 16 x 2-line LCD module. Power comes from a 5V USB supply, as used to charge tablets and mobile phones.

click, transfer it to the Micromite for testing.

Because it runs on a PC, MMEDIT is very easy to use, with colour-coded text, mouse-based cut and paste and many more useful features such as bookmarks and automatic indenting. And because the program is running on your PC, you can save and load your programs to and from the computer's hard disk.

Fig.5 shows MMEDIT in action. The most important feature is the right-hand button on the tool bar (the icon of a running man). When you click on this button, the program will be immediately transferred to your Micromite using the XModem protocol.

Following the transfer, a window will automatically open and connect to the Maximite's console where you can run and test your program. If there's an error or it needs tweaking, it's very easy to go back to the editor, make the changes and transfer it to the Micromite again.

MMEDIT can be downloaded from Jim's website at: http://www.c-com.com.au/MMedit.htm It's free although Jim would appreciate a small donation.

GPS-controlled digital clock

We needed a small project to demonstrate the potential of the Micromite and we decided that a digital clock which used a GPS module for accurate timekeeping was just the ticket. This GPS-Controlled Digital Clock uses just 10 components (including the connectors) so there's not much to it.

Fig.6 shows the circuit details. Most of the work is done in the Micromite which decodes the output from the GPS module, calculates the time zone offset and daylight saving and then drives an LCD which displays the date and time.

Considering just how few components are used, the result is impressive. The clock runs from a cheap 5V USB power supply and displays the time accurate to within a second. It never needs setting and it automatically compensates for daylight saving – just the thing for your office desk!

The important point to remember is that the program is not encrypted in a hex file that you cannot change. Instead, it's an easy to read BASIC program that you can modify to suit your requirements. For example, you might want to change how the time is displayed and this can be done with just a few keystrokes.

Alternatively, you might want to display the speed and heading from the GPS module instead of the time. Again, that's easily done with a few keystrokes. You could also extend the program to measure the room temperature and display that along with the time, all using the BASIC programming language.

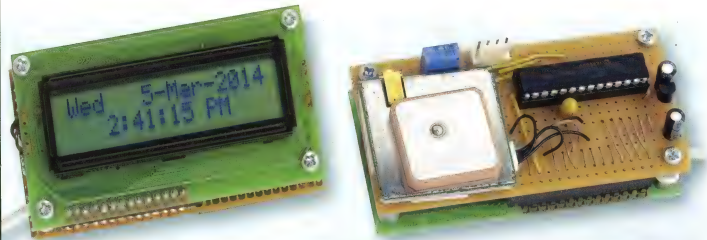
Recommended Micromite Microcontrollers

The following microcontrollers can be used for the Micromite:

- **PIC32MX150F128B-50I/SP:** maximum clock speed = 50MHz; 28-pin DIL package.
- **PIC32MX150F128B-50I/SO:** maximum clock speed = 50MHz; 28-pin surface mount SOIC package
- **PIC32MX150F128B-I/SP:** maximum clock speed = 40MHz; 28-pin DIL package.
- **PIC32MX150F128B-I/SO:** maximum clock speed = 40MHz; 28-pin surface mount SOIC package

The following microcontrollers will also run the firmware but only 17 I/O pins will be available in MMBasic:

- **PIC32MX250F128B-50I/SP:** maximum clock speed = 50MHz; 28-pin DIL package.
- **PIC32MX250F128B-I/SP:** maximum clock speed = 40MHz; 28-pin DIL package.



This is what our demonstration GPS-Controlled Digital Clock looks like. Because the program is written in BASIC you can easily modify how the time is displayed. The rear view at right shows just how simple it is. The Micromite and a GPS module do most of the work and there are just seven other parts plus the LCD module, all mounted on a small piece of stripboard.

Parts List: GPS Digital Clock

- 1 Micromite microcontroller (available from the SILICON CHIP Online Shop – see text)
- 1 2-line x 16-character LCD module (eg, Altronics Cat. Z7001 or Jaycar Cat. QP5512)
- 1 GPS module (eg, EM408)
- 1 3.3V fixed voltage regulator (MCP1700-330, LP2950CZ-3.3, etc)
- 1 47µF 6V tantalum capacitor.
- 2 10µF 6.3V electrolytic or tantalum capacitors.
- 1 10kΩ trimpot

Miscellaneous
USB cable, stripboard, spacers, machine screws & nuts

This photo shows just some of the devices that the Micromite has inbuilt support for and so are easy to add to your Micromite-based project. Shown is an infrared remote control, ultrasonic distance measuring sensors, a 2-line LCD display, a battery-backed real time clock (RTC) and a servo motor. Other devices not shown include temperature sensors, infrared transmitters and 4x4 keypads. The full details will be in part 2 next month.

There are many different LCD modules that you can use (with different pin-outs). For this reason, we didn't design a PCB but instead built the prototype on a piece of perforated strip board which we piggybacked on the back of the LCD module (see above photo).

The 5V DC power supply uses a USB charger/supply of the type used with mobile phones, book readers, etc. These are so cheap and plentiful these days that it's not worth designing a dedicated unit.

The supply is connected to the clock using a surplus USB cable. It's just a matter of cutting off the unwanted connector and soldering the wires direct to the board. The red wire is +5V and the ground is black, although you should check this first with a multimeter just to make sure. The other two wires are the signal leads and they can be cut short since they aren't needed.

The 5V supply is used to directly power the LCD module but the GPS

```
$GPGSV,3,1,12,11,75,324,36,01,59,146,27,32,58,161,34,20,56,209,30*75
$GPGSV,3,2,12,23,52,301,40,25,42,101,,13,23,311,23,17,19,237,23*72
$GPGSV,3,3,12,31,12,136,,19,08,358,13,14,06,136,,27,05,350,*72
$GPRMC,043359.000,A,3158.7597,S,11451.8693,E,0.29,58.06,101008,,*2B
$GPGGA,043400.000,3158.7598,S,11451.8693,E,1,05,3.4,25.0,M,-29.3,M,,0000*58
$GPGSA,A,3,23,20,13,11,32,,,,,,,,4.7,3.4,3.4*31
$GPRMC,043400.000,A,3158.7598,S,11451.8693,E,0.20,72.85,101008,,*25
```

Fig.7: this is a typical data stream from an EM-408 GPS module captured over one second. Each message is on a separate line and consists of the message type at the start followed by a number of data fields separated by commas. We are interested in the line beginning with $GPRMC as this contains the current date and time.

```
SUB GetGPSRecord
  DO
    DO WHILE INPUT$(1, #1) <> "$" : LOOP    ' wait for the start
    FOR i = 0 TO 20
     arg$(i) = ""                           ' clear ready for the data
     DO                                     ' loop until a specific exit
       x$ = INPUT$(1, #1)                   ' get the character
       IF x$ = "," THEN EXIT DO             ' new data item, new field
       IF x$ = "*" THEN EXIT SUB            ' end of record, so return with it
       arg$(i) = arg$(i) + x$               ' add to the data
     LOOP                                   ' keep going
    NEXT i                                  ' increment the field
  LOOP
END SUB
```

Fig.8: getting data from the GPS involves loops within loops. The result is that the global array arg$() is loaded with the contents of the GPS message one field to each element of the array.

module and Micromite require 3.3V so we obtained this from a simple 3-terminal regulator.

The LCD is wired with its read/write (R/W) line held low so that the module is always ready to receive data (we never read data from it). It's also connected in 4-bit mode so all data must be sent as 4-bit "nibbles". This detail is handled by MMBasic which has an inbuilt command to directly drive this type of display.

GPS output

Before we describe how the program works, we should quickly explain how a GPS module outputs its data.

Normally, the data is transmitted as a serial stream of characters at 4800 bits per second (bps). Some modules use 9600bps or even 19,200bps but they can be easily accommodated by editing the BASIC program.

The format conforms to the NMEA 0183 standard and an example data stream is shown in Fig.7. Basically, the data is formatted into a series of 1-line messages. Each message starts with a dollar symbol ($) and is terminated by an asterisk (*) followed by two hex digits that are a checksum.

The individual fields within a message are separated by commas. The first field is the type of message and for our clock project we need the RMC message which starts with the code word GPRMC. The RMC message is standard for GPS modules and they all generate it.

Other messages produced by a GPS module provide a variety of useful information including latitude, longitude, altitude and the number of satellites that the GPS module is listening to.

Within the RMC message we are particularly interested in the date (second field) and the time (tenth field). The third field is also important; it indicates if the module has a lock on the satellites and has an accurate time.

Capturing GPS data

Interfacing to the GPS module is done using the serial interface. The command **OPEN "COM1:4800" AS #1** will set that up for us.

We then need to capture each message and split it into the individual fields. This is done by the function GetGPSRecord() as shown in Fig.8.

Before this function is called, a string array has to be created with 20 elements in it. This array is called arg$() and the GetGPSRecord() function will fill it with the data fields of the message (one field to each element of the array).

We won't go through the detailed operation of this function but instead leave it as an exercise for the reader. However, the important section is the seventh line which gets a character from the GPS. Subsequent lines in the program examine this character to determine if it is the end of a field (a comma) or the end of the message (an asterisk), or if it is just part of a field.

Once this function has captured a complete message it returns to the caller (ie, the part of the software that triggered this function) which then checks the first field to determine if it is the required message type (more on that later).

Adjusting the time/date

The GPS unit provides the date and time as individual numbers (month, day, hours, etc). Once we have these numbers, we need to adjust them to take into account the local time zone and daylight saving (GPS data is always transmitted as UTC time).

Your first instinct might be to do this by adding the time offset to the hours field, then checking if it has overflowed and then adjusting the day of the month accordingly. However, this quickly gets complicated because you might have to adjust the month or even the year while taking into account leap years. And then there's the possibility of having to account for a negative time zone (ie, west of Greenwich).

Because the Micromite runs a powerful BASIC interpreter which can handle large numbers we simply convert the date/time into minutes since midnight on the 1st January 2014. As the years go by, this can become a very large number but MMBasic can cope with large numbers. In fact, it will be able handle the time in this format up to the year 2045 when it will be over 15 billion minutes.

With this conversion, it's then easy to add or subtract the time zone and make comparisons to see if the resulting time is subject to daylight saving adjustment.

The conversion itself is done by the function GetMins() which is shown in Fig.9. This function is supplied with

the year, month, day and time and returns with the number of minutes since the start of 2014.

We also need to know when daylight saving starts and ends and this is done by the function GetDST(), as shown in Fig.10. It is fed the current year, along with the month and hour that DST starts and ends. It then figures out what day the first Sunday of the month falls on. It then returns the number of minutes from the start of 2014 that daylight will start or stop.

For example, this year, daylight saving in Australia will start at exactly 400,440 minutes since the start of 2014. All we need then do is compare the current number of minutes with this number and if it is greater we need to add one hour for daylight saving (unless, of course, daylight saving has already ended).

Note that you'll need to set a flag (UseDST) in the software to indicate whether daylight saving is relevant to your area. Note also that the daylight saving calculations are correct for Australia and overseas readers will need to adjust the calculations to suit their local daylight saving rules.

Converting to time/date

Once we have the number of minutes (ie, representing the current time), we need to convert it back to the date and time format that we are familiar with (eg, 5th May 2014).

This is done with the GetDate$() and GetTime$() functions. Fig.11 shows the GetTime$() function which extracts the individual elements (hours, minutes and seconds) and then converts them to strings. By using the powerful string handling features of MMBasic, these are then joined together to make one complete string.

The GetDate$() function is similar in operation to GetTime$() and so is not shown here.

Putting it together

Now all we need to do is put all these functions together to make our main program which is shown in Fig.12. This starts by calling our function to get the next message from the GPS module. We want the RMC message which contains the time so we keep looping until we have that.

Inside the RMC message, we look at the third field which will contain the letter "A" if the module has locked onto sufficient satellites to get an accurate time. If not, we display a message on the LCD and jump back to find the next message from the GPS.

```
FUNCTION GetMins(yr, mth, day, hr, min)
  GetMins = (yr - 14) * (365 * 24 * 60) + ((yr - 13) \ 4) * (24 * 60)
  GetMins = GetMins + (md(mth) * (24 * 60))
  GetMins = GetMins + ((day - 1) * (24 * 60))
  GetMins = GetMins + (hr * 60)
  GetMins = GetMins + min
  IF (yr - 16) MOD 4 = 0 AND mth > 2 THEN GetMins = GetMins + (24 * 60)
END FUNCTION
```

Fig.9: this is how we convert date/time into a simple number, ie, the number of minutes since 1st January 2014. With this single number, it's much easier to change the time zone and detect when daylight saving begins and ends.

```
FUNCTION GetDST(yr, mth, hr)
  LOCAL d, m
  m = GetMins(yr, mth, 1, hr, 0)          ' minutes to the 1st day of the month
  d = ((m \ (24 * 60)) + 3) MOD 7         ' day of the week that this falls on
  GetDST = m + (((7 – d) MOD 7) * 24 * 60) ' minutes to the first Sunday
END FUNCTION
```

Fig.10: this function calculates when daylight saving (DST) will start or end. It takes the current year and the month and hour when DST starts/ends and returns the number of minutes to the first Sunday in that month. It's then easy to compare this number to the current date/time (in minutes) to determine if daylight saving has started or ended.

```
FUNCTION GetTime$(minutes)
  LOCAL hr, min, am$
  am$ = "AM"
  hr = (minutes \ 60) MOD 24
  IF hr > 12 THEN am$ = "PM" : hr = hr - 12
  IF hr = 0 THEN hr = 12
  min = minutes MOD 60
  GetTime$ = STR$(hr) + ":"
  GetTime$ = GetTime$ + RIGHT$("0" + STR$(min), 2) + ":"
  GetTime$ = GetTime$ + RIGHT$("0" + STR$(sec), 2) + " " + am$
END FUNCTION
```

Fig.11: this is how we convert the minutes value back into time, displayed as hours, minutes and seconds in 12-hour format. The function returns the result as a string of text characters which can be sent to the LCD for display. The GetDate$() function (not shown) does the same thing for the date.

Once we have an RMC message with an accurate time we can extract the year, month, etc as individual numbers. The GPS module provides this as a string (ie, a series of ASCII characters), so we convert them to numbers using the MMBasic VAL() function.

It's then quite simple to convert the data/time to minutes, add/subtract the time zone and adjust for daylight saving. Finally, this time is converted back to a string of characters and displayed on the LCD.

The **LCD** command is one of a series of powerful commands built into MMBasic for communicating with special hardware devices. In this case, the **LCD** command only needs to know the line on the LCD module to display the data, the length of the line (the C16 symbol means 16 characters) and the text to display.

The **LCD** command then does all the work required to transfer the text, centre it on the specified line and display it on the LCD module. It cannot get much easier than that.

This section of the program is contained within a loop which repeats forever. Every second, it will get an updated time from the GPS, convert the time and display it – forever looping.

Note that these code fragments don't show you the whole program but they do show how easy it is to write a program in MMBasic. If you want to build the GPS clock or examine the

Main Features Of The Micromite

(1) The Micromite is a fast 32-bit CPU with 128K of flash memory and 32K RAM running a powerful BASIC interpreter. 20KB of non-volatile flash memory is reserved for the program, while 22KB of RAM is available for BASIC variables, arrays, buffers, etc. This is sufficient for quite large BASIC programs up to 1000 lines or more.

(2) A full-featured BASIC interpreter with floating point and string variables, long variable names, arrays of floats or strings with multiple dimensions, extensive string handling and user defined subroutines and functions. Typically it will execute a program at 21,000 lines per second.

(3) Nineteen input/output pins are available on a 28-pin chip. These can be independently configured as digital inputs or outputs, as analog inputs or configured for frequency or period measurement and counting. Ten of the pins can be used to measure voltages and another seven can be used to interface with 5V systems. MMBasic can also be installed on a 44-pin version of the chip, providing 33 input/output pins.

(4) Programming and control via a serial console (TTL voltage levels) at 38,400 baud (configurable). Once the program has been written and debugged, the Micromite can be instructed to automatically run the program on power up with no user intervention. Special software is not needed to develop programs.

(5) Inbuilt full-screen program editor. This only requires a VT100 terminal emulator and can edit a full 20KB program in one session. It includes advanced features such as search and copy, as well as cut and paste to and from a clipboard.

(6) Easy transfer of programs from another computer (Windows, Mac or Linux) using the XModem protocol or by streaming the program over the serial console input.

(7) Input/output functions in MMBasic will generate pulses (both positive and negative going) that will run in the background while the program is running. Other functions include timing (with 1ms resolution), BASIC interrupts generated on any change on an input pin and an internal real time clock.

(8) Comprehensive range of communications protocols implemented including I^2C, asynchronous serial, RS-232, IEEE 485, SPI and 1-Wire. These can be used to communicate with various sensors (temperature, humidity, acceleration, etc) as well as for sending data to test equipment.

(10) Built in commands to directly interface with infrared remote controls, the DS18B20 temperature sensor, LCD display modules, battery-backed clocks, ultrasonic distance sensors and numeric keypads.

(11) Up to five PWM or SERVO outputs can be used to create various sounds, control servos or generate computer controlled voltages for driving equipment that uses an analog input (eg, motor controllers).

(12) Special embedded controller features in MMBasic allow the clock speed to be varied to balance power consumption and speed. The CPU can also be put to sleep with a standby current of just 80µA. During sleep, the program state and all variables are preserved.

(13) A watchdog feature monitors the running program and can be used to restart the processor if the program fails with an error or is stuck in a loop.

(14) The running program can be protected by a PIN number. This will prevent an intruder from listing or modifying the program or changing any features of MMBasic.

```
DO
 KeepSearching:
 DO
  GetGPSRecord                          ' get a GPS record
 LOOP UNTIL arg$(0) = "GPRMC"           ' we only want the RMC record
 IF arg$(2) <> "A" THEN                 ' "A" means valid record
  LCD 1, C16, "Searching"
  LCD 2, C16, "For Satellites"
  GOTO KeepSearching                    ' go back and keep looking
 ENDIF

 ' extract the elements of the date/time from the GPS record
 year = VAL(RIGHT$(arg$(9), 2))         ' extract the date
 month = VAL(MID$(arg$(9), 3, 2))
 day = VAL(LEFT$(arg$(9), 2))
 hour = VAL(LEFT$(arg$(1), 2))          ' extract the time
 min = VAL(MID$(arg$(1), 3, 2))
 sec = VAL(MID$(arg$(1), 5, 2))

 ' convert the time to minutes and add/subtract the time zone and daylight saving
 mins = GetMins(year, month, day, hour, min)
 mins = mins + TimeZone * 60            ' adjust for the timezone
 IF UseDST THEN                         ' if we observe daylight saving
  IF mins < GetDST(year, 4, 2) OR mins > GetDST(year, 10, 2) THEN
    mins = mins + 60                    ' adjust for AWST DST
  ENDIF
 ENDIF

 ' convert the minutes back into the current date/time and display it
 LCD 1, C16, GetDate$(mins)
 LCD 2, C16, GetTime$(mins)
LOOP
```

Fig.12: putting it all together. First, the correct GPS message is found, then the date/time is extracted as numbers representing the year, month, etc. These are converted to a minutes number which is then adjusted for the time zone and daylight saving. Finally, this time is converted back to text and displayed on the LCD. This loop repeats every second and never stops.

complete program, you can download it from the SILICON CHIP website (free for subscribers).

At the risk of labouring a point that we made earlier, it's easy to change these functions to display different data or change the format. All you need to do is connect an ASCII terminal and edit the program – then give it a run to see if it worked. That's the strength of the Micromite; it's incredibly easy to program.

Next Month

Next month, we will go into more detail on programming the Micromite. We'll also show you how to control it via an infrared remote control, how to measure temperature and much, much more.

Finally, for helpful tips and support check out the author's web page at http://geoffg.net/micromite.html SC

Intelligent Analog

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Analog design is difficult and consumes precious development time. Microchip's intelligent PIC MCUs integrate analog functions such as high performance Analog-to-Digital Converters (ADCs), Digital-to-Analog Converters (DACs) and operational amplifiers (op amps) providing simple-to-use interfaces that ease analog design. This single-chip solution enables reduced system noise and provides higher throughput, while dramatically reducing design time and cost.

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PRODUCT SHOWCASE

New low-cost Test & Tag Print Kit from Emona

Typically test and tag systems with tag printing capability cost several thousand dollars. For the first time, the PAC3760 DL data logging appliance tester and tag printing kit offers a solution that is around only $2,000.

The new PAC3760DL tester stores test results that download to any PC spreadsheet or database program. No special software is required to generate an electronic logbook to replace traditional handwritten logbooks.

The PAC3760DL also connects to the battery-powered PAC-OPT printer to print test tags. The PAC-OPT's unique "Plug N Print" operation simply requires connection to the PAC3760 DL via serial cable. Conduct your test and press the print button to output your test tag. No time consuming set-up is required as the PAC-OPT prints a generic test tag. With the PAC3760 DL, users will never have to handwrite log books and test tags again, easily the most time consuming part of testing and tagging.

The PAC3760 DL is based on the popular PAC3760 series of portable appliance testers used Australia-wide in testing and tagging for over 12 years. The DL's data logging and tag printing version builds on the range's long list of popular features. The PAC3760 DL conducts earth bond, insulation and polarity tests, as well as leakage current tests for Class I and Class II appliances and leads and carries out trip time tests of 10mA and 30mA portable and fixed RCDs with the inbuilt isolation transformer. When used in conjunction with the optional PAC-TPL 3-phase adaptor, the PAC3760 DL can also carry out 3-phase leakage testing of 10A, 16A, 20A and 32A 3-phase appliances. The PAC3760DL operates under mains or battery power, providing users with maximum flexibility.

Contact:
Emona Instruments Pty Ltd
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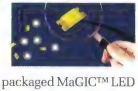
Tel: (02) 9519 3933 **Fax:** (02) 9550 1378
Website: www.emona.com.au

Tiny Plessey dotLED for Wearable Electronics



Plessey has launched its smallest packaged MaGIC™ LED (manufactured with GaN-on-Si I/C) aimed at the surging wearable electronics market. It's said to be not much larger than the full stop at the end of this sentence.

The PLW138003 is a 0.7lm white LED in a 1005 SMT package designed specifically for the demand for ever smaller LED components producing highly collimated light. Plessey's dotLEDs weighing 0.2 milligrams with a height of 0.2mm are an industry-leading option for any wearable application with LED content. It has a 130° viewing angle from 5mA of drive current.

The 1005-size of the PLW138003 (1.0mm x 0.5mm) is a standard electronic component size, handled by the common surface-mount assembly machines used in high volume consumer electronics. The Plessey dotLED is designed specifically for applications that demand low profile electronic components.

A blue version, the PLB138003 is also available. Further additions to the dotLED family will be colour variants and a series in the larger 1608 footprint. Plessey will also providesa range of blue LED dies shortly.

Contact:
Plessey Semiconductors
Tamerton Rd, Rodborough, Plymouth, Devon, UK
Tel: (0011 44) 1752 693000
Website: www.plesseysemiconductors.com

10 x 5.5m hi-res LED Screen at The Star

The largest in-house hi-res LED screen has been installed at The Sydney Star's Event Centre. The modular screen, comprised of 220 panels of 5mm LEDs, can be up to 10m wide x 5.5m high. Its flexibilty offers events at the centre the highest quality digital offerings in virtually any format.

The Star also acquired a Christie Digital Spyder M20X processor to service the screen and it is backed by (and seamlessly integrates with) the Event Centre's four Christie 20K projectors. The full-size screen takes only an hour and a half to set up.

The Star has also purchased multiple trusses, capable of holding the screen in a variety of formats out on Sky Terrace, adjoining the Event Centre.

The screen was a feature of the ARIA and AACTA awards held in late 2013 and early 2014.

Contact:
The Star Event Centre
80 Pyrmont Street, Pyrmont NSW 2009
Tel: (02) 9777 9000 **Fax:** (02) 9482 1309
Website: www.star.com.au/star-event-centre

First 40GHz Cable/Antenna Analyser

Claimed to be the first handheld cable and antenna analyser with frequency coverage up to 40GHz, the Microwave Site Master S820E provides frequency coverage of 1MHz to 40GHz. Anritsu is developing Vector Network Analyser (VNA) measurements for the analyser. The optional software will enable field measurements such as full-reversing two-port S-parameters and time domain with gating. A vector voltmeter and A/B ratio will also be part of the software.

Designed for measuring coaxial and waveguide systems, the analyser conducts key one-port measurements, such as return loss, VSWR, cable loss, DTF, phase, and Smith Chart. Users can also conduct two-port transmission measurements and two-port cable loss tests. The analyser has the company's easyTest Tools that enables tests to be standardized for repeatable measurements, as well as Line Sweep Tools for simplified reporting. Dynamic range is 110dB up to 40GHz, which brings benchtop instrument performance into the field, says the company, to address today's wireless networks. Frequency resolution is 1Hz and the frequency coverage provides high-resolution distance resolution, so the handheld analyser can conduct more accurate distance-to-fault (DTF) measurements.

The processor allows the analyser to have a sweep speed of 650µs/data point, improving field productivity. RF immunity is +17dBm, claimed to exceed any other microwave handheld cable and antenna analyser. The analyser measures 273x199x91mm and weighs 3kg.

Contact:
Anritsu Pty Ltd
21/270 Ferntree Gully Rd, Notting Hill, Vic 3168
Tel: (03) 9558 8177 **Fax:** (03) 9558 8255
Website: www.anritsu.com

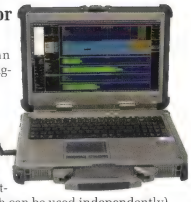
Australian company launches world's most secure online storage solution

A Brisbane company has launched a revolutionary online storage solution that is claimed to provide unmatched security for cloud-based computing.

"Your Digital File" brings never-before-seen technology to offer the most secure online storage and document trading system. Your Digital File provides a revolutionary layer of protection called Cryptoloc. Everything clients save in Your Digital File is automatically scrambled, so the files can't be opened and read without a password-protected digital private key that is generated and saved to the client's computer when they sign up to Your Digital File. The private key unlocks and decrypts the scrambled files. Clients access their files from the device on which they joined Your Digital File. The service is also portable – clients can download their private key onto a USB stick.

Contact:
Your Digital File
GPO Box 187, Brisbane, Qld 4001
Tel: 1300 791 915
Website: www.yourdigitalfile.com

Ultra rugged outdoor Spectrum Analyser



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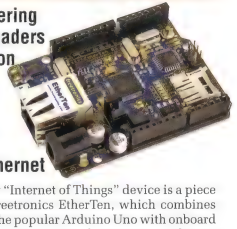
Freetronics offering SILICON CHIP readers 20% Discount on EtherTen Arduino-compatible development boards with Ethernet



Prototyping a new "Internet of Things" device is a piece of cake using the Freetronics EtherTen, which combines the functionality of the popular Arduino Uno with onboard Ethernet, a micro-SD card slot and Power-over-Ethernet support.

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If you enter the discount code "SC14A" at the Freetronics website www.freetronics.com/etherten , they'll give you a 20% discount on the EtherTen!

Contact:
Freetronics
PO Box 7067, Croydon South Vic 3136
Website: www.freetronics.com

SERVICEMAN'S LOG

A close shave for a fancy shaver

Dave Thompson*

Rescuing a device that would otherwise end up on the e-waste mountain is always satisfying, especially when the fault is simple. However, simple faults are not always simple to find, as this problem in a client's battery-powered shaver demonstrates.

Items Covered This Month

- Battery-powered shaver repair
- Power supply tester repair
- Submersible bore pump
- Samsung SCX-4828FN laser multi-function centre

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One of my earliest memories of my Dad is him sitting at the table shaving with one of those battery-powered electric shavers that were all the rage back in the seventies. Advances in battery technology during that era meant that everything from radios to hair driers could be made portable and the advent of the battery-powered electric shaver meant that men could shave anywhere without being tied to the bathroom or a power point.

Dad's shaver was a dual-head model made by a very well-known company (they still make updated versions of the same model). It was powered by four AA-size cells, all neatly packed into a textured black plastic case which also formed the grip. The unit also featured a handy mirror embedded into the inside top of the brushed aluminium cover; not that I recall Dad ever using it.

It had a solid, good-quality feel about it, right down to the sliding on/off switch and the rounded case which had been worn smooth by years of use. I can remember the distinctive sound it made as if it was only yesterday and, in fact, I'm reminded of it regularly. I still have that shaver and in occasional fits of nostalgia take it out of the drawer, fit it with fresh batteries and fire it up to make sure it's still working as it should.

I've kept it all these years for the same reason Dad did before passing it on to me; it's just too good to throw away. The motor is still strong, the blades keen and it works just as well as it ever did.

Over the years, I've purchased a couple of other portable shavers with the intention of retiring the old one but I've yet to find one that does a better job. During that time, I've gone through a couple of sets of shaving heads (and lots of batteries) but that's the advantage of buying good-quality products; every part for this model is still available from the manufacturer.

For better or worse, that was the sort of quality built into many such products back in the seventies. These days, everything is made with in-built obsolescence and in the cheapest way possible; I've seen shavers for sale that would be lucky to last two years of regular use let alone 10 or 20.

Shaver service

So what's all this leading up to? Well, a customer recently brought in a shaver for me to see if it could be fixed. It was a top-of-the-line model and a replacement would cost a small fortune.

Unfortunately, this particular unit had taken a tumble during one of the quakes and now it wouldn't go at all. It had a microswitch on/off button and when this was pushed, nothing happened. It also showed no signs of charging when placed into the accompanying cradle (or charging dock), the front-panel charge-indicator LEDs remaining off.

The whole thing looked very futuristic and oozed expensiveness, which is why the owner wanted me to see if anything could be done. Throwing something like this away seemed wrong, especially if it could be easily fixed.

I immediately suspected that the problem was simply a flat battery. I've seen this hundreds of times on laptops where the charger has failed and despite the owner plugging the charger in, nothing happens. Eventually, the battery discharges to the point where pressing the power button results in either nothing at all happening or just the briefest blink of the indicator LEDs before the residual battery power fades away.

In this case, the customer reported that much the same thing happened with his shaver. When he pressed the on/off button, the charge indication LEDs sometimes briefly flashed before going dark but usually he got nothing at all. This suggested that a battery recharge was all it needed to get it going again.

The first thing I had to determine was whether the charger was delivering the required power to the shaver. A multimeter placed across the charging contacts gave a reading of around 4.5V, so that cleared the charger (or charging dock) itself. That meant that there must be something in the shaver that was preventing the battery from charging.

In fact, I was glad that this was the case because the charging dock appeared to be clipped together (rather than screwed) and opening it up would likely have resulted in something being broken. At the very least, some of the curved edges would have been disfigured by the tools used to prise it apart.

By contrast, the shaver itself was relatively easy to disassemble. Three long PK-style screws with those

weirdly-shaped safety heads held the body together and removing them was a doddle. Fortunately, I had the right bit for this job otherwise it would have been impossible as the screw heads are buried well into the case.

The top assembly, which included the three shaving heads and a trimmer arrangement, was held in place by three large plastic clips. These took some wrestling to get apart as they were arranged so that they all opposed each other. If one was unclipped, annoyingly it would reattach itself while I was working on one of the others (three hands would be very handy in cases like this). Once free though, the heads, gearbox, motor and battery/PCB assembly all came out in one piece.

The charging connections were my staring point. In this shaver, these consisted of two polished metal rods embedded into opposite sides of a clear moulded plastic insert that held all the main components together. When the shaver sat in the dock, these two rods made contact with the corresponding charging nodes. There wasn't much metal showing in either case but because the thing sat so snugly in the charger, enough contact was made to get the job done.

The plastic work was an impressive piece of engineering. My dad at one point in his working life made dies for his own injection-moulding machine and I used to watch him as he milled intricate cavities into solid blocks of steel and turned endless metal shapes on his lathe (which now sits proudly in my own workshop). As a result, I can appreciate how such things are made and the tolerances with which they are manufactured.

In this case, all those metal parts embedded in the plastic would have had to have been held in place in the die somehow as it was closed and the plastic injected into it. And that is a feat in itself. No doubt, these days such parts would be computer milled on hyper-expensive C&C machines or even 3D-printed but it is a beautiful work to behold nonetheless.

Because the two metal charging rods were held firmly in place and the wire connections were integrated into the main plastic block, it was unlikely that it would be something as simple as the charging connections coming loose. Besides, I could see right through the plastic and everything looked quite solid in there.

I don't know much about shaver circuitry but I thought that if I put a meter across the two charging rods, I would get some indication, even if the battery was flat. However, when I did this, the meter needle didn't budge. Either I was mistaken in my assumptions or something between these points and the battery was broken.

At this point, a quick web search turned up a few shaver circuit diagrams (although not for this particular model). These diagrams indicated that while some shavers had reverse-polarity protection (using an in-line diode), I should still expect to see something across the charging points.

With this in mind, I dug deeper and focused on the battery/PCB assembly that was now dangling free of the rest of the shaver on two short black motor wires. I disconnected these and this then allowed me to remove and examine the PCB assembly more closely.

I also noted that the motor's polarity was marked with a large red "+" symbol on its body. However, since the PCB assembly only went in one way and the motor leads were just 25mm long, it was unlikely I'd get them transposed when I reassembled it later on. So in this case, I didn't bother taking a picture or drawing a diagram.

The assembly itself consists of a PCB sandwiched between a white moulded plastic battery support on the top and

Samsung SCX-4828FN laser multi-function centre

You win some and you lose some! A. P. of Toowoomba, Qld recently lost one when he tackled a Samsung SCX-4828FN multi-function centre but it wasn't for want of trying . . .

Carli brought me her Samsung SCX-4828FN laser multi-function centre (MFC) with the complaint that all the copies came out white. I immediately asked whether she had tried printing anything to it and she said that she had and that the printer section worked fine.

That meant that the scanner was probably faulty and so I suggested that it might be better to simply buy a new one, as spare parts for these things are expensive. What's more, new MFCs with equivalent functions had dropped from the $700 or so that Carli had paid five years ago to $350 or less today. Even so, I said that I would take a quick look at it in case the fault could be rectified without needing to buy parts.

I began by lifting up the automatic document feeder (ADF) to expose the flatbed scanner glass. I then turned the machine on and the scanner sensor flashed through various colours and moved back and forth to calibrate its position. The brightness of this light show seemed a bit dimmer than I remembered from other scanners but I couldn't say for sure that this wasn't normal for this model.

About 20 seconds after power-up, the LCD panel announced that the machine was ready to copy. I placed a printed page face down onto the flatbed glass and pressed "Start". The scanner sensor moved across the page and the printer spat out a blank sheet of paper. I also tried to scan using the automatic document feeder (ADF). Scanning using the ADF moves the paper past the scanner sensor, which remains stationary at one end of the scanner bed. However, the result was the same: another blank sheet of paper.

Interestingly, the unit was not reporting any faults in the scanner in spite of this.

Next, I set about installing the relevant drivers on a PC so that I could separately test the printing and scanning functions. As expected, the printing function worked, while scanning again produced blank pages. This eliminated the possibility that the problem was caused by a firmware bug that only affected the photocopying/scanning function.

Having done that, I now decided to dismantle the scanner section, in case the problem was caused by a flat cable that had worked loose from its connector or there was some other obvious fault problem (eg, a fractured cable). The first step was to remove the ADF. There is a cable connecting it to the rest of the works and this is removed by simply unclipping a small panel on the scanner glass bezel which reveals the connector.

The lower flaps of the ADF's hinges slide up and down inside the main unit, to accommodate thick objects like books. However, if the ADF is tilted while the lower hinge flaps are fully-extended, the hinges come free of the main unit and the ADF can then be lifted clear.

The bezel holding the scanner glass is secured by two screws at the rear (near the ADF's hinges) and another two at the front that are hidden under the rear edge of the control panel. It's therefore necessary to first remove the control panel, which is held only by plastic clips along the front and by the scanner glass bezel along the rear. This apparent chicken-and-egg problem is resolved by releasing the plastic clips at the front and angling the control panel up to enable it to slide out from under the scanner glass bezel.

Two cables connect to the control panel. One goes to a photo-interruptor that is used to calibrate the position of the scanner sensor, while the other connects to the processor board inside the main unit. These are simply unplugged at the control panel end.

The remaining two screws securing the scanner glass bezel were then accessible. By the way, all the screws that I removed were identical, making it particularly easy to reassemble the unit later.

Now that the scanner glass was out of the way, I was able to inspect the scanner's contact image sensor (CIS) carefully and make sure that the flat cable that connects to it was indeed securely held in its socket.

I also wanted to verify that the other end of the CIS cable was securely connected to the processor board. This can only be done with the righthand panel removed from the main unit but first the scanner unit has to be separated from the main unit. That's done by removing two screws from the rear and sliding the scanner unit towards the back to free it. The righthand panel has only a back-lit display underneath. This display features four icons, each one indicating a function or the current status of the shaver. The PCB boasted a surprising amount of electronic parts for a shaver, though I assume most of it was to drive the display.

All the parts on the PCB were surface-mounted and everything was coated in a rock-hard, epoxy-like substance. Like the rest of the device, it was well made, compact and firmly clipped together, so it was very unlikely to move about.

This also meant that if any of these parts were blown or broken, I'd have to replace the entire module. And just by looking at it, I knew it wouldn't be a cheap spare part.

It was looking increasingly likely that I'd be passing bad news on to the customer and the thing would end up in the bin. Unfortunately, this is becoming all too common in my line of work. We are living in an increasingly throwaway society and here again it looked like we would be discarding a perfectly repairable device simply due to the price (or perhaps even non-availability) of spare parts.

As an aside, a classic but somewhat tragic example is evident at my brother's printer supply and repair company. Out the back, he has a literal mountain of printers that for the sake of a $2 part here and there are all

one screw in it, near a socket where the panel wraps around to the rear, so I removed it and found that the panel could then be gently eased off without any tools required.

Removing the righthand panel revealed the processor board, including the connector for the other end of the CIS cable. I removed and re-inserted this cable to ensure it was making a good connection, then re-tested the photocopying function but it was still making blank copies.

The next thing to check was that the CIS cable was intact. I pulled both ends from their sockets and tested the continuity of the conductors with my DMM. It was fine.

Not seeing anything wrong with the electronics, I now considered that the fault could lie in the firmware. The processor board sported a CR2032 lithium cell, which was presumably used to maintain the time and date and possibly other settings. I removed it and waited 30 seconds before reinserting it but this had no effect other than that when I next powered the unit up, it required the date to be entered.

So far I had been "flying blind" without a service manual but now I wanted to find out if it was possible to reflash the firmware. My theory was that a glitch in the firmware could result in blank scans while flying under the radar of the unit's self-test procedure.

Searching the internet resulted in two useful pieces of information. The first was the service manual, which I downloaded onto my smartphone. The second was that the problem of blank scans was relatively common for this model and although various people had asked for help in solving this problem, there didn't appear to be any solutions. I soldiered on in spite of this discouraging news.

With the service manual at my disposal I found that the magic incantation to bring up "tech mode" is "MENU # 1 9 3 4 #". Using "tech mode" I was able to clear all memory, which might conceivably have fixed the problem but didn't. I was also able to perform a DRAM test (it reported 128MB), a ROM test (it simply showed the version number of the firmware [1.01.00.22] without being clear whether a checksum was calculated) and a shading test.

The shading test is used to calibrate the scanner's contact image sensor. For each of the sensor colours, it prints a 'curve' consisting of the relative response of each pixel in the image sensor. The manual shows actual curves but this unit printed four ruler-flat lines (for mono, red, green, and blue). This is consistent with the blank scans being either a hardware fault (open circuit cable or faulty CIS) or a firmware fault (eg, in the device driver for the CIS).

The final and most useful function that I was looking forward to from "tech mode" was to be able to upgrade the firmware. The service manual shows a firmware upgrade option as being available in this mode and it's quite flexible, being able to upgrade from a USB connected PC or remotely via fax from another identical model.

Unfortunately though, the SCX-4828FN under repair had no firmware upgrade item in the "tech mode" menus. I couldn't imagine that it would be possible to force an upgrade of the firmware without giving permission via the front panel, so that really seemed to be the end of the line.

In the event, I soon proved myself wrong about it being impossible to force a firmware upgrade. There are a significant number of websites selling or giving away alternative firmware for various models of printer and multifunction centres, for the explicit purpose of circumventing the restrictions on using third-party toner cartridges. I happened on one of these sites by sheer accident, and discovered that not only were they giving away updated firmware (version 1.01.0031f) for the SCX-4828FN but also that the upgrade process was initiated entirely by an attached PC.

The only prerequisite was that the SCX-4828FN had to be turned on and ready to copy.

I downloaded the necessary files, connected my laptop to the MFC, and initiated the upgrade. The whole process went smoothly and took about five minutes, during which the LCD on the MFC indicated the progress by showing the addresses of the blocks that it was erasing and programming. That's the good news. The bad news was that after the upgrade, the scanner was still producing blank copies.

That exhausted almost every possibility except the one that would cost real money: the contact image sensor was now the most likely suspect. I removed it from the scanner and read the part number from the bottom. Googling gave me a number of suppliers but unfortunately the cheapest price I could find was over $100 delivered. And without any guarantee that this was indeed the faulty part, I didn't feel inclined to invest that much in the repair.

In the end, I returned the MFC to Carli with the advice that she purchase a brand new replacement unit. I also suggested that she use the faulty unit purely as a printer until the current toner cartridge was empty.

destined for landfill – all because the manufacturer has decided not to make some parts available as spares.

In such cases, the only repair option is to burgle another identical device for the wanted part. However, many of these things fail for exactly the same reason, so having an identical unit available doesn't always guarantee a result. As a result, the device gets thrown onto the mountain along with the others. Add this mountain to the many others around the world and that's a lot of e-waste to get rid of.

Getting back to the job on hand, there had to be a reason for this shaver no longer charging and hopefully it wouldn't require an expensive (or unavailable) spare part, or result in a trip to the e-waste mountain.

The shaver's display unit and battery holder were both secured to the PCB using plastic clips and these were relatively easy to prise free, giving me an unhindered look at both sides of the assembly. Under a magnifying glass, the board looked perfect; there were no visible cracks or physical damage, nor any burn spots or discoloured areas which could indicate overheating. This was both good and bad news. The good news was that there were no obviously burnt or broken parts but the bad news was that the problem still lurked somewhere.

A voltage check across the lithium-

ion (Li-Ion) battery terminals gave a reading of 2.8V, well below the 3.7V it should have been. It was obviously not being charged and when placed in the charging dock, the voltage across the battery remained the same.

My next step was to check the voltage across the terminals on the PCB, where the tags from the battery were soldered in. However, I couldn't get a reading until I applied pressure to the positive end of the battery and then things lit up. This looked more promising; there was obviously something awry in the battery connection itself.

I soon had it nailed it down; a strap is spot-welded to each end of the battery and this then passes through and is soldered onto the PCB. The strap on the positive end of the battery had come completely adrift but was sitting so close to the battery terminal that it looked to be connected. When the meter probe was pressed against it, it did connect and I got a reading.

I clipped the parts back together, sat the whole assembly in the charging dock and pressed down on the positive battery terminal. The charging lights immediately came on. When I released the pressure, they went out again. What surprised me was that everything looked completely sound because the battery was held firmly in place and the strap was positioned such that it looked to be connected. As I discovered, it was only a gnat's whisker away from making contact but that was enough.

This created a new problem; soldering anything to battery terminals like this is notoriously difficult. It requires a very hot iron, lots of scraping to get a clean metal surface and a healthy dollop of corrosive flux in order to get a half-way decent connection. Unfortunately, hot irons and Li-Ion batteries aren't a good mix and considering that the local electronic components retailer stocked a replacement battery complete with straps for $18 plus shipping, it seemed foolish to persevere with such a potentially explosive job.

The customer agreed and once I'd obtained the battery it was a simple matter to solder it in, reassemble the components and fire up the shaver. It immediately sprang into life, even on the battery's relatively low residual "shelf-charge" of 3.2V.

So, in the end, the fix was relatively simple and it's nice to know that this high-end piece of man-cave kit didn't end up as another dead device on an e-waste mountain.

Power supply tester

Saving faulty test equipment can be well worthwhile, even if it's a low-cost unit that's not worth a professional serviceman's time. B. P. of Dundathu, Qld was recently given a faulty digital PC power supply tester which he soon got going again . . .

I was visiting my mate Tim at his appliance repair shop and we were talking while his apprentice got ready to test a computer power supply. Unfortunately though, he plugged the P4 connector into the wrong socket of the digital tester he was using and it immediately expired, emitting a puff of smoke and an accompanying acrid smell in the process.

He quickly removed the power but it was too late; the damage had been done. Tim took it all in his stride and simply handed his apprentice a new tester out of the drawer, telling him to be more careful next time. He was about to throw the damaged unit in the bin, when he paused and grabbed a good power supply and plugged it in. He found that the tester's LCD backlight no longer worked, while the 12V2 was flashing and showing 11.9V instead of flashing 'LL' as it should with the second 12V connector disconnected.

I asked him if he was still going to bin it and he said "yes", so I said I would take it and have a look at it, to see if it was repairable.

I tackled it as soon as I got home. It was an aluminium case type, with plastic ends. The plastic ends are removable but you have to be careful not to break the retaining clips. There is also a hidden screw under a sticker and once this and the ends have been removed, the PCB simply slides out of the case.

I turned the PCB over and could immediately see that a track had been 'blown off'. There was no other obvious damage, so I decided to replace the missing track with a length of insulated hook-up wire and see what happened; perhaps that would fix it!

Once the link was in place, I grabbed a known good PC power supply, plugged it in and connected the digital power supply tester to the 24-pin connector. The tester's LCD backlight now worked and the 12V2 was now flashing 'LL' as it should. I then plugged in the P4 connector and the 12V2 reading came up as 11.9V, which was the same as the 12V reading.

Next, I tried the SATA plug and a Molex plug and this resulted in the appropriate LEDs lighting. This all meant that the unit was now working correctly so I reassembled it and put it in the drawer with my other power supply testers.

That's another damaged piece of test gear saved from the bin and I now have a spare digital power supply tester. What's more, it cost me nothing other than about 30 minutes of my time.

GPS antenna repair

J. H. of Burwood East, Victoria recently damaged the GPS antenna that fed a chart plotter on his 48-foot yacht. Here's how he got it going again . . .

It's usually desirable to have a reli-

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able chart plotter on board a yacht. On my 48-footer, the chart plotter's GPS antenna was located on the rear pushpit rail where people often put their arm across it and consequently attenuated the satellite signals. To eliminate this problem, I therefore decided to move the antenna to a more optimum position on the same pushpit.

First, I found that although the antenna cable was long enough, it had to be released by removing numerous cable ties. These were mostly in extremely difficult locations in the lazarette, in the stern of the vessel.

After that initial struggle, I had sufficient cable but the antenna fitting had to be changed from a horizontal mount to a vertical mount to suit the new location. Because the cable passed through the old mount, this meant that it had to first be disconnected from the antenna unit.

As Murphy decrees, any change to electronic equipment *must* demand a new fitting that is incompatible with the old fitting. And it must cost money and take considerable effort to fit. Of course, in a marine environment, it's better to avoid connectors and use direct solder connections instead.

Opening the GPS antenna by removing the outer protective covers showed the coax cable's outer shield engulfed by an extremely impressive amount of solder. The back of a yacht is not a place for large electrical soldering equipment, so in desperation I used a fine hacksaw to cut the coax away from the antenna and the PCB.

The next step was to clean the antenna, replace the fitting, re-route the coax through this new fitting and resolder the coax feed. The result after all my hard work was total failure of the chart plotter system. There were no satellite signals or even a vague smell of one, even after half an hour.

Obviously, somehow, I had destroyed the antenna. Unfortunately, suitable replacement antennas didn't seem to be available, either from retailers or over the internet.

Cursing myself, I then searched the internet and visited many marine shops to see if I could locate a new (cheapish) chart plotter. The outcome was that I would have to spend $1000 - $2500 for a new (colour) plotter, followed by the hassle of running cables and installing new fittings. Anyone who has worked on a boat realises that this is an extremely challenging task, particularly when these cables often have connectors that won't fit through small openings.

Following more strong words and an almost sleepless night, I decided that if the antenna had been damaged then I might as well have a go at fixing it. This would involve removing it and bringing it home so that I could examine it under better conditions.

Back on the boat, I undid the mechanical components and cut the coax feeder in order to remove the antenna. Once it was on my workbench, I removed the cover and found that the antenna is built on a ceramic disc about 50mm in diameter. The upper, antenna side is embedded with a flat plate some 30mm square and on the other side is a PCB, which is in the shape of one quadrant of an 80mm-diameter circle. The flat plate has a wire connected near its centre and this goes to the PCB through an insulated hole.

The PCB side of the ceramic disc is metal-plated and the PCB is attached to this via seven through-hole soldered joints. As a result, each soldered hole was progressively heated and the PCB slowly prised away from the ceramic with the aid of five carefully positioned razor blades. After about an hour's careful work, I had the PCB separated from the metal side of the ceramic disc!

This immediately revealed that the PCB was double-sided and metal-plated where it faced the ceramic disc. I then discovered that the flat plate antenna is DC electrically connected to ground. The undamaged and unmarked circuit board indicated that this connection is deliberate.

Using a high-power magnifying glass, I closely examined each of the surface mount (SMD) components and soon discovered what looked like a coil that could have been damaged. Unfortunately, this component was further damaged during its removal from the PCB.

On the internet, I found "Wheeler's Formula" for calculating the inductance of air-cored coils. I then measured the removed coil with my vernier calliper and came up with dimensions of 0.06 x 0.08 x 0.09 inches (the formula stipulates inches). I then calculated the coil diameter and hence, for five turns, a total inductance of approximately 0.045mH.

My local parts retailers have RF chokes but the smallest is 1mH and is physically too big to fit. So, using a piece of insulation from standard hook-up wire as a former and my thinnest varnished copper winding wire from my junk box, I wound a small 7-turn coil. A dab of Tarzan's Grip then secured the winding, after which I removed the former and soldered the legless coil into place on the PCB. I then completed the repair by soldering the PCB back onto the ceramic disc and remade the antenna connection.

Back at the boat, I soldered the coax feed cable to the PCB and then turned

Fixing a power-hungry submersible bore pump

After receiving an unusually high electricity bill, R. H. Mont Albert, Victoria recently took on the repair of a submersible bore pump. Here's what happened . . .

The quarterly electricity bill for our holiday house arrived the other day. I was astonished to find that it was $617.80, nearly $400 more than the previous bill which was $227.12. We hadn't been there any more than usual, so it was very puzzling

My first reaction was to blame the electricity supplier for putting up the charges but even that wouldn't account for such a massive increase. Then I looked more closely at the bill and realised that the rate of $0.2605 per kWh hadn't changed. Instead, we had used 1930kWh during those three months, compared with around 500kWh the previous three months.

There was obviously something wrong, so I checked the meter reading. It had been read just four days prior and the reading seemed to be correct. Some quick calculations then showed that this bill meant we were using an average 21.44kWh/day but the previous average was 5.6kWh/day. I read the meter again and realised that we had used 88kWh since the meter reading on the bill. So whatever the problem was, it was still there.

It was time for some troubleshooting, so I started turning appliances off one by one, checking the meter (an old analog type) each time as I did so. When I turned the fridge off, the rotating disk slowed right down. Haha, I thought there's the cause of the problem. We had stacked a lot of frozen food in the freezer section and these were against the fan outlets.

Then, just when I thought I'd solved the problem, the meter disk suddenly sped up again, despite the fridge being switched off. As a result, I now turned off everything at the wall, including the TV, clocks, radios, the oven and any battery chargers for batteries on float. Still the disk spun.

But why? Everything had been switched off except for one thing – the bore pump. But that shouldn't be causing the high electricity consumption since, with all the taps off, no water was being pumped. Turning off the switch immediately stopped the spinning disk, so that's where the fault did indeed lie.

The bore is equipped with a submersible pump and a pressure switch, so that when a tap is turned on the pressure drops and the pump switches on. Checking the pressure gauge showed that it was at full pressure, as expected. What's more, the gauge wasn't moving so the pressure wasn't dropping due to a leak and turning on the pump. There also wasn't any sign of water leaks anywhere.

Next, I connected my energy meter to the bore lead and found that it was using 850W. This increased to 1250W when a tap was turned on and it was pumping water but it remained stubbornly at 850W when the tap was turned off.

During these tests, I noticed that the pressure gauge didn't move so I noted the make and model and went on a fruitless internet search. There were many places I could buy a pressure switch but very little information on how to test the one I had or troubleshoot it.

I needed to examine the switch itself but this was difficult as the bore controller is hard up against the garage wall. I ended up using a small mirror to help remove the cover and check for any obvious signs of damage but nothing was apparent.

It was time to get serious. After unplugging the bore pump from the mains and turning on a tap to de-pressurise the system, I removed the pressure switch from its housing. It looked fine and a test with my multimeter showed that it was 'on'. This was correct, since there was no pressure.

Despite my trepidations, I then decided to take it apart. It only had four screws holding it together so I carefully removed these and disassembled it, being careful to note how all the small pieces fitted together. This wasn't entirely successful because several springs and various small plastic pieces immediately jumped onto the workbench. They had obviously been imprisoned for a long time and were intent on escape.

Further dismantling showed that salt build-up was blocking a small hole that led to a diaphragm that activated the switching mechanism. As a result, the diaphragm couldn't move which meant that the pump ran continuously, even though there was nowhere to pump the water.

So the problem was really quite simple. It could have been a lot worse, particularly if the pump itself had been at fault as it's some 30 metres down the bore hole.

I wondered if the same problem explained why the pressure gauge always indicated high pressure. Sure enough, with no pressure in the fitting where the gauge was attached, it still indicated 120 PSI. I removed it and cleaned the salt build up and it went back to zero.

My next problem was to reassemble the pressure switch after it had all been cleaned. After a frustrating hour or so, I finally got it back together and reconnected it to the bore plumbing. And to my relief, it worked. The bore pump now only uses power when pumping water and none while the taps are off.

Yesterday a letter arrived from the electricity supplier to say that prices are going up! You just can't win!

on the chart plotter. You can image my disappointment when there was no result. Feeling desperate, I then read the handbook which stated that, on initial start-up, it might take 10 minutes or so for the chart plotter to register satellites.

After about five very tense minutes, the first satellite appeared, much to my relief. It was followed shortly after by eight more, all at full strength! My GPS antenna was back in action. SC

ONLINE & IN STORE

Prices valid until 23/05/2014

MEGA MAY!

3D Printer - Bring your 3D Creations to Life!

Supplied as a DIY kit, once assembled you can turn 3D digital images into real life plastic objects. A very fast, reliable and precise 3D printer that won't break the bank.

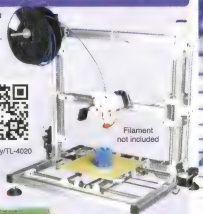
Can print objects with maximum dimensions of 200 x 200 x 200mm, in either ABS or PLA plastics (available separately).

This is an advanced level constructional kit, average build time is 3 - 4 days. For more information on assembly and the tools required please visit our website. Extensive online community support is also available at: www.k8200.eu

TL-4020

$1299 NEW

http://bit.ly/TL-4020



5.8GHz Wireless AV Sender

SAVE $10

Transmits audio/video signals up to 50m clear line of sight. Interference free. Compatible with most PayTV systems and AV equipment. Built-in infrared extender.

AR-1878

WAS $99.00

$89.00

Spare Receiver AR-1879 $69.00

3D Printer Controller Module

Allows you to operate your TL-4020 without a PC!

Features an SD slot for file loading, preassembled but cable connection requires soldering.

TL-4022

$149.00

Note: You will still require a PC to slice and prepare the 3D file.

Australian & New Zealand Exclusive to Jaycar!!!

3D Printer Filament

Available in two diameters, 1.75mm and 3.00mm, in either ABS or PLA material. Supplied on a 1kg roll.

TL-4060 **1.75mm PLA** $44.95
TL-4062 **3.00mm PLA** $44.95
TL-4070 **1.75mm ABS** $42.95
TL-4072 **3.00mm ABS** $42.95

Coming soon!

3D Printer LED Light

Illuminate your object whilst printing. Suitable for TL-4020.

TL-4024

$34.95 NEW

Jaycar Electronics

Better, More Technical

2.4GHz Wireless Reversing Camera with DVR

Easy to install, 4.3" monitor, front and rear facing cameras, event recording camera as well as a reversing camera. 2.4GHz for clear video.

NEW

- Up to 50m range
- Infrared camera for day/night use

QM-3850

Also available: 2.4GHz Wireless Reversing Camera NEW QM-3852 $199

$229.00

3 Port Ethernet Adaptor

Extend your home/office network over your mains power line. Simply plug the adaptor into a mains outlet then connect to your router. Features 3 x 10/100Mbps RJ-45 ports.

- Energy saving mode if no data is transmitted
- Operating range: Up to 300m

YN-8354 NOTE: Mains wiring must be on the same circuit phase

NEW

$129.00

1700 Lumen Long Beam LED Lights

Tough, compact LED lights which can be bolted onto your 4WD, car or off-road buggy. The deep optic reflector lens gives far more beam distance than other LED spotties. Aluminium alloy housing.

- Equipped with CREE® MT-G LED
- IP68 rating
- Stainless steel mounting hardware included

Flood Light - SL-3932
- Beam distance: 178m

Spot Light - SL-3930
- Beam distance: 490m

Sold separately

NEW

$129.00 ea

Compact CatIII 600V Multimeter

Budget-priced meter packed with features.

- 4000 Count
- AC/DC Voltage 600V
- AC/DC Current 10A
- Resistance, capacitance, frequency & temperature
- Non-contact voltage
- Backlit LCD

QM-1323

$39.95

700 Lumen Rechargeable Torch

High power and fully adjustable beam spread. Finished in black with a tactical switch for mode adjustment. Battery, charger and mains power supply are included.

- Equipped with CREE® XML LED
- Size: 128(L) x 38(Dia.)mm

ST-3485

NEW

$49.95

Economy 4 Channel DVR

An affordable 4 channel DVR for home or office surveillance. Connect to a computer network to view video remotely from anywhere in the world using a web browser or Smartphone/iPhone® (via free installed app). Includes 500GB of storage for up to 300 hours of continuous video recording from up to 4 cameras (**QC-3339 $59.95 each** available separately).

- Manual, scheduled or movement activation
- USB/HDMI connection
- Size: 300(L) x 210(W) x 50(H)mm

QV-3049

$249.00

Battery Saver Kit

Ref: Silicon Chip Magazine Sept 2013

Cuts off the power between the battery and load when the battery becomes flat to prevent the battery over-discharging and becoming damaged. Suitable for use with cordless power tools, emergency lights, small to medium UPS (up to approx 300VA) and a wide variety of other devices.

- PCB: 34 x 18.5mm

KC-5523

$29.95

Soft Start Kit for Power Tools

Ref: Silicon Chip Magazine July 2012

Stops that dangerous kick-back when you first power up an electric saw, router or other mains-powered hand tool. This helps prevent damage to the job or yourself when kick-back torque jerks the power tool out of your hand. Kit supplied with PCB, silk screened case, 2m power cord and specified electronic components.

- 240VAC 10A
- PCB: 81 x 59mm

KC-5511

$49.95

Theremin Synthesiser Kit MkII

Ref: Silicon Chip Magazine March 2009

Create your own eerie science fiction sound effects by simply moving your hand near the antenna. Easy to set up and build. Complete kit contains PCB with overlay, pre-machined case and all specified components.

- Requires 12V power supply **(MP-3147 $17.95)**
- PCB: 85 x 145mm

KC-5475

$74.95

Digital Multimeter Kit

Learn everything there is to know about component recognition and basic electronics with this comprehensive kit. From test leads to solder, everything you need for the construction of this meter is included. 9V battery included.

- Meter size: 67(W) x 123(H) x 25(D)mm

KG-9250

$24.95

ARDUINO Development Kits

StepDuino Arduino Compatible

A self-contained board with onboard stepper motor drivers, servo interface, microSD card slot, and 20x4 character LCD. Perfect for building robots or other mechatronics projects: just connect the stepper motors and go!

- 2 x 4-wire stepper motor controllers
- 1 x servo interface
- Serial communications header
- Compatible with the Arduino IDE
- Size: 113(W) x 74(H) x 25(D)mm

XC-4249

NEW

$149.00

Eleven

The "Eleven" is just like an Arduino Uno - but better! It's a microcontroller board based on the ATmega328 with 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

XC-4210

$39.95

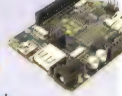
USBDroid with Onboard Android/USB Host

Specially designed to be compatible with the Android Open Accessory Development Kit. Connect your Android device like a mobile phone for all kinds of controller and networking features.

- Built-in charger

XC-4222

$69.95



Blue Dot Matrix LED Display Panel

This large, bright 512 LED matrix panel has onboard controller circuitry designed to make it easy to use straight from your board.

- 32 x 16 high brightness blue LEDs (512 LEDs total) on a 10mm pitch
- Viewable over 12 metres away

NOTE: Can for comparison only

XC-4251

Also available **Red Large Dot Matrix LED Display Panel** XC-4250 $39.95

$89.95

16 x 2 LCD Display

Handy 16-character by 2-line display ready to plug straight into your Arduino, with a software-controllable backlight and 5 buttons for user input. The display can be panel mounted if required.

- Software-controlled blue backlight

XC-4218

$29.95

Jacob's Ladder MK3 Kit

Ref: Silicon Chip Magazine Feb 2013

CAUTION HIGH VOLTAGE

A spectacular rising ladder of bright and noisy sparks for theatre special effects or to impress your friends. This improved circuit has even more zing and zap than it's previous design from April 2007 and requires the purchase of a VS Commodore 12V ignition coil (available from auto stores and parts recyclers). Powered from a 12V 7Ah SLA **(SB-2486 $29.95)** or 12V car battery.

- Kit supplied with silk-screened PCB, diecast enclosure (111 x 60 x 30mm), pre-programmed PIC, PCB mount components and pre-cut wire/ladder

KC-5520

$49.95

Battery not included

Kits for Kids

Salt Water Fuel Cell Engine Car Kit

An educational kit demonstrating the concept of a salt powered automotive engine. Assemble, add salt water, and off the car goes!

- Suitable for ages 8+

KJ-8960

$19.95

Ramp not included

Water Powered Vehicle Kit

Build up to 13 different water powered vehicles and watch them move! This kit demonstrates water jet power and hydro pneumatic power in a fun and simple way.

- Suitable for ages 8+

KJ-8913

$39.95

Short Circuit Book & Parts

Includes book with 20+ projects, baseboard, plenty of spring terminals and ALL the components required to build every project in the book, INCLUDING the bonus projects.

- Requires batteries

KJ-8502

$39.95

Savings off original RRP. Limited stock on sale item.

Ethernet Switches

Enhance network performance and efficiency. Mains powered or via USB port. Supports auto-negotiation and cable length detection. Includes power supply and USB power adaptor.

- 5VDC
- 8 x RJ-45 ports
- Compact size 137(L) x 76(W) x 25(H)mm

NEW

8 Port 10/100Mbps N-Way Switch
YN-8077 $24.95

8 Port 10/100/1000Mbps N-Way Gigabit Switch
YN-8078 $59.95

24 Port Ethernet Switch

- 24 x 10/100 Ethernet ports
- Auto-negotiation & auto MDI/MDIX support
- Dynamic buffer limiting
- Mains adaptor included

YN-8083 **WAS $99.95** SAVE $10

$89.95

Improve Your Wireless Broadband Reception

Eliminate Wi-Fi dead zones and extend the range of existing networks. Signal strength LED to locate best position.

- Wi-Fi strength LED indicator
- WPS (Wi-Fi Protected Set-up)
- Mains powered

Universal Wi-Fi Extender

- 10/100Mbps Ethernet LAN port
- Range, extender & Wi-Fi bridge
- Includes RJ-45 network lead

YN-8360 **WAS $69.95** SAVE $10

$59.95

Universal Dual Band Wi-Fi Extender

- 300Mbps
- 2.4GHz/5.0GHz
- Low interference, less lag & more stable Wi-Fi
- User Access Control

YN-8364 NEW

$89.95

Multi-Network Cable Tester

Designed to quickly test UTP/STP/Coaxial/ Modular network cables by manually or automatically scanning the wires for continuity, incorrect wiring and polarisation.

- Pin out indicator
- Requires 1 x 9V battery

XC-5076

$39.95

CAT5-E Blue Patch Leads

Suitable for most Ethernet and LAN home or office applications. Lengths from 0.5m to 30m available.

FROM $3.25

- RJ45 to RJ45
- 350MHz & ACMA approved

0.5m	YN-8200	$3.25			
1.0m	YN-8201	$3.95	**10m**	YN-8205	$14.95
2.0m	YN-8202	$5.25	**15m**	YN-8206	$21.95
3.0m	YN-8203	$6.95	**20m**	YN-8207	$24.95
5.0m	YN-8204	$8.95	**30m**	YN-8208	$37.95

Also available in red, yellow and green colours. See in store or online for details.

USB 3.0 Male A to Micro B Lead

Connects your computer to the latest micro-USB 3.0 peripherals, such as external HDD's, printers and scanners.

NEW

- 1.8m

WC-7774 $14.95

Cat 5 UTP Splitter

Enables two different devices to share the same Cat 5 cable.

YT-6090 $16.95

NOTE: Cannot be used to run two computers from one network.

Intelligent Routers

Combines three networking tools into one: Wi-Fi range extender, Wi-Fi access point or a wired/wireless router. Fully supports 802.11b/g/n standards and provides excellent wireless coverage.

- 1 x RJ-45 Fast Ethernet WAN port
- 4 x RJ-45 Fast Ethernet LAN ports
- WPS (Wi-Fi Protected Setup)
- WEP, WPA & WPA2 encryption

FROM $39.95

NEW

150Mbps 802.11n Wireless Broadband Router
YN-8325 $39.95

300Mbps 802.11n Wireless Broadband Router
YN-8327 $59.95

PoE Passive Kit

PoE (Power Over Ethernet) allows you to power wireless access points or other equipment via a Cat 5 cable without the need to have a separate power source available.

- Includes input and output leads
- 2.1mm DC plug/socket

YN-8410 $19.95

Wi-Fi Extender - Ceiling Mount

A high-speed solution for broadening coverage and eliminating dead spots in a home or office Wi-Fi setup. Fully compatible with 802.11n protocol. Speeds up to 300Mbps and functions as an access point and repeater at the same time.

- 5VDC power supply included

YN-8362 **WAS $99.00** SAVE $10

$89.00

USB 3.0 Gigabit Ethernet Adaptor

Provides a high performance 10/100/1000Mbps Ethernet connection for your laptop, desktop, MacBook®, or tablet.

- Size: 45(L) x 25(W) x 15(H)mm

YN-8408 $49.95

400A AC/DC Clampmeter

Quality, intermediate-level clampmeter with useful current ranges up to 400 amps AC and DC. Perfect for the working installer or tradesman.

- Cat III, 600V
- Temperature: -20°C to +760°C (±3%)
- Data hold, non-contact voltage, relative measurement

QM-1563

$119.00

Digital Tyre Gauge

Measures tyre pressure in four units (PSI, Bar, kgf/cm, kPa) and tyre tread depth to determine tyre change required.

- Backlit LCD display
- Pocket-sized

QP-2297 **WAS $14.95**

$9.95 SAVE $5

PCB Holder

An extra pair of hands and eyes for those fiddly jobs. Supports PCBs while soldering etc. Great for model builders and other hobbyists.

- 145mm high

TH-1983

PCB not included

$12.95

Super Pro Gas Soldering Tool Kit

Contains a Portasol Super Pro Gas Soldering Iron and various tips.

- 1300°C temperature max
- 40 second heat up
- Quality storage case
- Cleaning sponge and tray

TS-1328

$159.00

Non-Contact Thermometer

An easy way to compare the temperature between surfaces. Excellent for diagnosing refrigeration systems, automotive cooling systems, hotspots in mechanical equipment, etc.

- Temperature range: -50 - 260°C (-58 - 500°F)
- Audible and visual warning
- Backlit flip-up LCD

QM-7211 **WAS $119.00**

SAVE $20

$99.00

Moisture Level Meter

Can be used on timber, cardboard, paper and even on hardened materials such as concrete and mortar. A bar graph extends up the screen indicating the amount of moisture.

- Easy to read display

QP-2292 **WAS $69.95**

SAVE $10

$59.95

PCB Etching Kit

An ideal kit for anyone needing to etch a circuit board - complete with an assortment of double-sided copper boards, etchant, working bath and tweezers. See website for full list of inclusions.

HG-9990

$27.95

Digital Frequency Counter

2.7GHz dual range frequency counter for measuring functions of frequency, period totals and self checking. Large 10mm high intensity 7 segment LED display. Data hold function. ABS case.

- Frequency range: 10Hz - 2700MHz
- 8 digit LED

QT-2202 **WAS $169.00**

SAVE $20

$149.00

Gas Leakage Detector

Gas leaks can be incredibly dangerous. This unit detects butane, propane, acetylene and methane (natural gas) gases.

- Visual/audible warning
- Requires 2 x AAA batteries

QP-2299 **WAS $39.95**

$34.95 SAVE $5

LED Illuminated Magnifying Lamp

Magnify and illuminate objects. Great tools for technicians, researchers or for general hobby work that involves soldering, connecting wires between small parts, and other fiddly jobs.

- 5 dioptre lens
- Mains powered

QM-3548

$99.00

Temperature Controlled Soldering Station

An ideal entry-level soldering station for the hobby user. Comes with a lightweight iron with anti-slip grip and tip cleaning sponge.

- Temp range: 150°C-450°C
- 40W power
- Size: 135(L) x 82(W) x 70(H)mm

TS-1620

$59.95

Spare 0.5mm conical tip: TS-1622 $8.95

Polyurethane Potting Compound

Designed to electrically insulate and protect against dust and moisture.

- 70ml

NM-2016

$9.95

Circuit Board Lacquer

Protect circuit boards from humidity and environmental attack.

- Non CFC ozone safe propellant
- 175g

NA-1002

$11.50

Dust Remover

Remove dust from electronic, electrical & optical devices.

- Non CFC
- Non toxic
- Non conductive
- 250g

NA-1018

$24.95

Freezing Spray

Instant freeze for rapid cooling of components.

- Non CFC ozone safe propellant
- Non-flammable
- 250g

NA-1000

$24.95

Coaxial Adaptors

PA-3675 PA-3653 PA-3672 PA-3671

PAL Plug to RCA Socket
PA-3675 $3.95
PAL Plug to F-81
PA-3653 $3.95
F-59 Plug to PAL Socket
PA-3672 $1.95
F-59 Plug to PAL Plug
PA-3671 $2.95

FROM $1.95

Heavy Duty Coax Crimping Tool

For crimping connectors onto coax cable for TV and communications applications.

- Adjustable crimp force
- 3 hex dies

TH-1832

$29.95

Waterproof ABS Cases - Black

Use for storing or transporting Smartphones, radios, delicate electronic devices and more.

- Protective foam

SMALL: 182(L) x 120(W) x 42(H)mm
HB-6421 $16.95

MEDIUM: 182(L) x 120(W) x 75(H)mm
HB-6423 $19.95

LARGE: 655(L) x 482(H) x 495(H)mm
HB-6425 $29.95

FROM $16.95

RG6 75 Ohm Coax Cable

Great for domestic TV & pay TV installations! Austar/Foxtel approved.

- 30m roll

WB-2014

$44.95

Also available per metre. **WB-2009 $1.80/m**

BE REWARDED

As a way of saying thank you – everyday – we've put together a loyalty programme called Jaycar Rewards. Earn a point for every dollar spent at any Jaycar Store* and be rewarded with a $25 Rewards Cash Card once you reach 500 points.

Register online today by visiting www.jaycar.com.au/rewards

*Only available from Jaycar company owned stores. See website for full T&Cs.

Polycarbonate Sealed Boxes

- Designed to IP65 (dust proof)
- Moulded in light grey
- Operating temperature: -40 to +125˚C

82(W) x 80(D) x 55(H)mm
HB-6230 $12.95

115(W) x 90(D) x 55(H)mm
HB-6216 $14.95

171(W) x 121(D) x 55(H)mm
HB-6218 $19.95

222(W) x 146(D) x 55(H)mm
HB-6220 $29.95

FROM $12.95

HDMI Adaptors

PA-3640 PA-3642 PA-3644 PA-3649

HDMI Socket to Socket
PA-3640 $16.95
HDMI Plug to DVI-D
PA-3642 $16.95
HDMI Socket to DVI-D Plug
PA-3644 $16.95
Mini HDMI Plug to HDMI Socket
PA-3645 $9.95
Micro HDMI Plug to HDMI Socket
PA-3649 $9.95

FROM $9.95

HDMI Plug to HDMI Socket Swivel Adaptor

Connect HDMI cables where space is an issue such as wall mounted TV's.

- Gold plated connectors

PA-3647

$12.95

Automotive Relays

6-Way Membrane Switch Panel with Relay Box

An ultra compact 6-way 12VDC touch control panel to control devices in automotive, camping, or marine applications. Waterproof (IP67 rated) on the switch panel.

- Built-in resettable fuses
- Max current: 10A per channel, 35A total

SP-0900

$99.95

Universal Relay Wiring Kit with Switch

Fits various 12V devices to your car such as our LED driving lights. Cables are fully protected inside a loom tube.

- Max current rating: 7A (80W)

SY-4079

$29.95

Racing Ignition Switch Panel

Complete ignition switch panel ready to install in your car. Push button engine start, missile launch ignition on and indicator light.

- Size: 95(W) x 66(H)mm

SP-0774

$29.95

HDMI Leads

High quality HDMI 1.4 cables with gold plated connectors and oxygen-free copper cabling.

- Male to male

0.5m	WQ-7906	$24.95
1.5m	WQ-7900	$29.95
3.0m	WQ-7902	$39.95
5.0m	WQ-7904	$49.95
10.0m	WQ-7905	$79.95

FROM $24.95

CONCORD

Ventilation Fans

- 240VAC
- Diecast aluminium housing

80mm Ball Bearing - 2 Wire

YX-2508

$36.95

120mm - Solder Lugs

YX-2514

$28.95

120mm Thin - Solder Lugs

YX-2516

$29.95

120mm Ball Bearing - Solder Lugs

YX-2517

$36.95

150mm Ball Bearing - 2 Wire

YX-2520

$84.95

Hands Free Microphones

Panel Mount Bluetooth® Receiver with Microphone

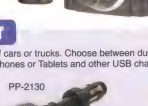
Allows you to stream music from any Bluetooth enabled device over your car/marine radio. Features a microphone for hands free calling. One-knob volume and track control.

- 12V
- Bluetooth 3.0

AR-3129

$49.95

NEW



Stereo Bluetooth® Hands Free Car Kit

Plugs into the car's MP3/AUX 3.5mm jack for hands free functionality with any Bluetooth® enabled Smartphone.

- 12/24VDC
- Bluetooth 4.0

AR-3130

$39.95

iPhone® not included

NEW

Cigarette Lighter Power

Range of 12/24VDC adaptors to suit a variety of cars or trucks. Choose between dual and triple outlet models, some with USB ports to charge Smartphones or Tablets and other USB charged gadgets.

Cigarette Lighter Socket Splitter
Powers two or three 12/24VDC accessories at the same time.

2 Way Splitter PP-2130 $9.95
3 Way Splitter PP-2135 $12.95

PP-2130

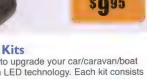
FROM $9.95

Cigarette Lighter Socket Splitter Cable
Powers two or three 12/24VDC accessories at the same time.

2 Way Splitter Cable PP-2132 $14.95
3 Way Splitter Cable PP-2134 $19.95

PP-2132

FROM $14.95



Cigarette Lighter Socket With USB
Power a USB gadget while still keeping your cigarette lighter socket available. 2A max.

Single Port PP-2126 $9.95
Dual Port PP-2128 $19.95

PP-2128

FROM $9.95

Auto Security

Suitable for cars, boat and truck applications.
- 12/24VDC

NEW

Waterproof Siren - 90dB

Designed for harsh environments.

- Spade lugs
- 40mm (Dia.)

LA-8901

$10.95

Mini Reverse Warning Siren - 90dB

Extremely easy to install. Features a mute function that you can connect to the parker lights to mute the siren at night time if desired.

- Fly leads
- 55mm (Dia.)

LA-8904

$9.95

NEW

Waterproof Siren - 97dB

Features an ambient background level control which changes the volume between 75 and 97dB depending on the environmental noise.

- Fly leads
- Size: 101(W) x 72(H) x 42(D)mm

LA-8903

$34.95

NEW

Waterproof 2-Way Deutsch Connector Set

Perfect for connecting up sensors/lights in the engine bay due to their superior corrosion protection and waterproof properties.

- 13A

PP-2150

$6.95

NEW

Car Lighting Kits

Fantastic little kits to upgrade your car/caravan/boat interior lighting with LED technology. Each kit consists of an array of cool white LEDs on a board with 3M adhesive foam backing.

- Universal T10/211/BA9S
- 12V

NEW

FROM $9.95

2.5W 260 Lumens (shown)
ZD-0585 $9.95

3W 310 Lumens
ZD-0587 $12.95

4.5W 450 Lumens
ZD-0589 $14.95

1080p Mini Car Event Recorder

Low cost, compact with a 1.4" LCD screen, capable of recording in full HD. Records to a microSD card (sold separately) up to 32GB. Adjustable G-Force sensor. Built-in battery. Car adaptor supplied.

- Size: 110(H) x 65(W) x 50(D)mm

QV-3846

$79.95

NEW

2.4GHz Digital Wireless Reversing Camera Kit

Digital signal provides clear video, better range and security. Simple installation, 12V power for camera, cigarette lighter socket power for monitor. All size vehicles. Add up to 4 cameras (sold separately) for increased visibility.

- 3.5" colour LCD
- 100m range

QM-3802

$179.00

Spare camera QM-3803 $79.00

10 Way Blade Fuse Block with LED Indicators

Features a common supply rail and includes a removable protective cover and LED indicators for each fuse.

- 100A (max) input
- 30A (max) output

SZ-2008

$19.95

Also available:
Waterproof Fuse Block with LED Indicators SZ-2001 $24.95

Fuses not included

2 x 60 Amp Circuit Breaker

Offers a lower voltage drop than a fuse and can be used as an occasional circuit isolation switch.

- 3 x 4 gauge input
- 2 gauge output

SZ-6000

$29.95

12V LED Trailer Light Kit

Stop, tail, turn and number plate illumination. Kit includes 2x trailer lights, with a pre-made 7m trailer cable with 7 pin flat trailer connector.

- ADR approved
- Screw stud mount

ZD-0722

$59.95

Universal Programmable Battery Charger

Charges, discharges and balances Li-ion, Li-Po, Ni-Cd, Ni-MH and lead acid batteries. Particularly suited to radio control hobbies. It can be powered with a mains plugpack or directly from a 12V battery or any other DC source from 10 - 18 volts.

- Microprocessor controlled
- Delta V charging detection
- 2, 3, 4, 5 and 6 cell balanced charging outputs

MB-3632

$79.95

All in One Battery Tester

Tests the capacity of all types of batteries currently on the market including AA/AAA/C/D/9V, button cells and lithium batteries such as those used in digital cameras.

- LED indicator

QP-2253

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Batteries not included

12VDC Power Supplies

Suitable replacements for lost, old or broken adaptors. Used in thousands of different applications.

- Regulated 12VDC output
- 240VAC input

Supplied with 7 plugs:
1.5A MP-3486 $21.95
2.5A MP-3490 $29.95

Supplied with 5 plugs:
5.0A MP-3243 $64.95 (shown)

FROM $21.95

4 Outlet USB Mains Power Adaptor

Single power adaptor that provides 4 individual USB charging sockets, with up to 4.5A total charging current.

- Size: 85(H) x 55(W) x 44(D)mm

MP-3454

NEW

$29.95

SLA Batteries

High quality sealed lead acid (SLA) batteries for standby, emergency and back-up power applications. Great value!

6 VOLT

1.3 AMP HOUR	SB-2495	$12.95	(shown)
4.0 AMP HOUR	SB-2496	$14.95	
12.0 AMP HOUR	SB-2497	$29.95	

12 VOLT

1.3 AMP HOUR	SB-2480	$19.95	
2.2 AMP HOUR	SB-2482	$22.95	
4.2 AMP HOUR	SB-2484	$27.95	
6.0 AMP HOUR	SB-2485	$24.95	(shown)
7.2 AMP HOUR	SB-2486	$29.95	

FROM $12.95

Other sizes available in-store & online.

USB Power Bank with 5000mAh Battery

- Charges 2 devices at once
- 2A and 500mAh USB port
- Adaptor included

MB-3644

$39.95

Lead Acid Battery Charger

This fully automatic charger will charge 2V, 6V and 12V sealed and standard (car) lead acid batteries. Output lead has battery clips for easy charging. Ideal to trickle charge your car battery while on holidays.

- 600mA charging current
- Short circuit and wrong polarity protected
- Approval number: N19029

MB-3518

$24.95

Battery Discharge Protector

Protects a car battery from total discharge by switching off appliances such as fridges and TV sets before the battery voltage drops to an unrecoverable level.

- Operating voltage: 12VDC
- Max. switching current: 20A

AA-0262

$39.95

Flexible Solar Panels

These 12V flexible solar panels offer performance at an affordable price. No heavy rigid frame makes them light and portable. Both units have a fully sealed terminal box with approx 1.2m of power cable with PVC outer sheath.

20W
- Short circuit current: 1.24A
- Weight 0.78kg

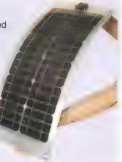
ZM-9112 $99.95

100W
- Short circuit current: 5.69A
- 2.8kg

ZM-9116 $399.00

FROM $99.95

NEW



5A DC-DC Converter with USB

Converts 24VDC to 12VDC so you can use accessories designed for 12V vehicles. Has a USB output with 1A current to charge your mobile phone or other USB device.

- 5A max output current
- 12VDC output voltage

MP-3354

$49.95

Also available: 10A 24VDC to 12VDC Converter MP-3352 $69.95

Snap On Battery Terminals

Used for protecting the exposed positive/negative battery connections from dust, grime or other build up. Ideal for automotive, marine, or industrial use.

- Rated at 500A
- Red and black supplied

HM-3087

Battery not included

$14.95

Battery Switches with Enclosure

Simple 2 and 4 position battery switches for controlling battery power on your boat. Ideal if you have one battery for starting the engine and another for auxiliary electrical equipment. Durable design.

2-Position SF-2246 (Shown) $29.95
4-Position SF-2248 $39.95

FROM $29.95

SLA Battery Boxes

Designed to suit larger SLA batteries or your standard car battery. Perfect for mounting in your boat, trailer or caravan. Includes mounting clamps and lid strap to secure the box properly in place.

Battery box to suit 40Ah SLA Batteries HB-8100 $24.95

Battery box to suit 100Ah SLA Batteries HB-8102 $29.95

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2.4GHz DIGITAL Wireless HDMI AV Sender

Transmit high definition 1080p audio and video signals from your HD equipment to your HDTV or HD monitor up to 100m away. Built-in IR receiver/extender.

- 2 x 1m HDMI leads included
- Up to 1080p output resolution
- Size: 151(L) x 116(W) x 26(H)mm

AR-1871

$169.00

TV Wall Bracket 180° Swivel

Extend, rotate and tilt. Ideal for corner mounting. Allows for +/-2° lateral roll to ensure the TV is perfectly level after installation. Suits panels 32" to 60" - up to 80kg.

- Solid steel construction
- Mounting hardware and instructions included

CW-2825

$149.00

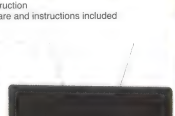
Indoor Flat Panel Digital Antenna

Capable of picking up UHF and VHF signals as well as DAB+ radio signals. Features 2 adjustable antennas and a standard PAL adaptor as well as a separate amplifier which may be required for areas with weaker indoor reception.

- Signal clear technology
- Extremely low noise circuitry

LT-3156

$39.95



Economy HDMI Leads

Cost-effective solution without compromising quality or performance. Gold plated connectors. HDMI 1.4 standard with Ethernet classification.

1.5m	WV-7915 $19.95
3.0m	WV-7916 $24.95
5.0m	WV-7917 $39.95

FROM $19.95

HDMI Over Cat 5/6 Extender

Extend your HDMI signal up to 60m* using a single CAT 5/6 cable. Both unshielded twisted pair (UTP) and shielded twisted pair (STP) cables may be used, however shielded is recommended.

- Supported resolution: 480p, 720p, 1080i, 1080p
- Mains adaptor included

AC-1681 **WAS $149.00**

NOTE: *Distance will vary depending on the resolution and cable specifications used. See website for full specifications.

SAVE $20

$129.00

Dual Channel UHF Wireless Microphone

Two-channel system supporting two separate microphones. Each channel has a separately balanced XLR output. Includes two microphones and batteries, receiver unit and plugpack.

- Wireless range: 60m

AM-4078

WAS $149.00

SAVE $20

$129.00

Audio Converters

TOSLINK/Coaxial Audio Converters

Achieve compatibility between devices which have different digital audio inputs and outputs.

- Power supply included

TOSLINK to Coaxial Digital Audio Converter

- Input via TOSLINK, output via RCA socket

AC-1598 $24.95

Coaxial to TOSLINK Digital Audio Converter

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AC-1599 $29.95

FREE* Fibre Optic Lead (WQ-7299) worth $14.95

FROM $24.95

*Valid for purchase of AC-1598 or AC-1599

USB 2.0 Audio Converter

Allows you to output audio from your PC or Apple® computer in high fidelity 24-bit 192kHz audio via USB.

- Input: USB 2.0
- Output: 6.35mm headphone, 2 x RCA and TOSLINK

AC-1616

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SAVE $20

$69.00

Analogue to Digital Audio Converter

Converts 2 x RCA stereo audio inputs to S/PDIF TOSLINK optical and S/PDIF RCA coaxial outputs. Perfect for connecting devices that lack digital audio to speaker systems which only accept digital audio.

- Power supply included

AC-1596

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*Valid for purchase of AC-1596

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Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details. Savings off Original RRP.
Prices valid from 24th April 2014 to 22nd May 2014.

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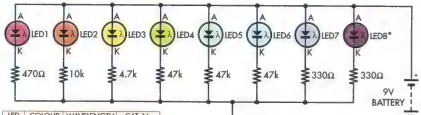
Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock.

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



LED	COLOUR	WAVELENGTH	CAT. No.
LED1	DEEP RED	660nm	ZD0152
LED2	RED	625nm	ZD0154
LED3	ORANGE	590nm	ZD0162
LED4	GREEN	525nm	ZD0172
LED5	AQUA	505nm	ZD0178
LED6	BLUE	470nm	ZD0182
LED7	VIOLET	405nm	ZD0260
LED8	(UV)	370nm	370-5R15*

* This LED from VioLED International, Taiwan (www.violed.com)

Demonstration of LED spectra

The colours of the new LED traffic lights are quite distinct from the old incandescent ones. Green seems brighter and more bluish, while red seems brick-red rather than orange-red. This is because LEDs give relatively "pure" light over a narrow range of wavelengths, while the bandwidths of the filters for the old incandescent lights are much broader.

Here's a simple and inexpensive device to help understand the relationship between colour and the wavelength of light. It consists of eight LEDs covering the entire visible spectrum, built in a small plastic box. The red LED traffic lights are 660 nanometres (nm) and the green LED traffic lights are 505 nm, often referred to as "aqua" (Fig.1).

The series resistors for the LEDs have been selected to equalise their perceived brightness, since the efficiency of the LEDs varies greatly. The ultraviolet LED lies outside the visible spectrum and is not essential, but it is included to illustrate the point that not all light is visible. It was obtained from VioLED International in Taiwan (www.violed.com) and costs less than $2 in small quantities, while all others are from Jaycar.

The latest Jaycar catalog comes with coloured spectacles for viewing the 3D printer-created object on the front cover. If you close one eye and look at the LED box through the blue side you will see that it is a long pass filter that blocks out the red LEDs at 625nm and 660nm but passes all shorter wavelengths (Fig.2). And if you close the other eye and look through the red filter, you will see that it is transparent to wavelengths of 525nm and longer but it also allows some violet light of 405nm to pass (Fig.3).

Fig.1

Fig.2

Fig.3

This device should be useful for teaching the basic principles of colour. Since children may forget to turn it off, I suggest the use of a "momentary contact" push switch.

James Goding,
Carlton North, Vic. ($40)

MAY THE BEST contribution WIN!

As you can see, we pay $$$ for contributions to Circuit Notebook. Each month the BEST contribution *(at the sole discretion of the editor)* receives a **$150 gift voucher from Hare&Forbes Machineryhouse.** That's yours to spend at Hare&Forbes Machineryhouse as you see fit - buy some tools you've always wanted, or put it towards that big purchase you've never been able to afford!

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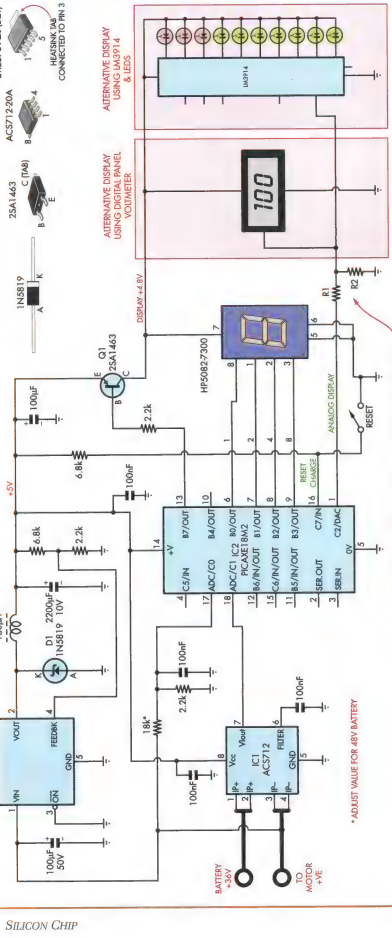


Battery capacity meter for electric bikes

This Battery "Fuel Gauge" was developed for use with an electric bike but has applications in other areas. Typically, most 'e-bikes' are equipped with a voltmeter but this is not very useful for estimating state of charge. The circuit operates as a "coulomb counter" to estimate the state of charge of the battery. This continually monitors the discharge current and time, to estimate the charge that has been used.

By subtracting the used charge from the battery's fully-charged (rated) capacity, the remaining capacity, or "state of charge" of the battery, can be estimated. However, instead of using coulombs, the project uses the more familiar charge unit called "ampere hours" or "Ah".

This technique does not require the estimation of power used and does not depend on the battery voltage. To put it simply, if a charged battery has a rated capacity of one amp hour (1Ah), and we have measured a drain of 0.5A for 1 hour, we can estimate that about 0.5Ah has been used and there is 0.5Ah remaining. Excluding depth of discharge requirements, this is about 50% remaining.

The circuit indicates how much charge is remaining as a percentage of the full charge capacity (ie, amp hours). Two display outputs are provided: (1) a single digit value (4-bit BCD) representing the 10's digit of % remaining and (2) an analog output giving a voltage proportional to the remaining charge. The analog output can be used directly with a display such as a digital panel meter or a LED bargraph such as provided by an LM3914.

The multi-tasking capabilities of the new PICAXE 18M2 enables the controller to sense when power is switched off and to save the current (pun) value of remaining charge while still providing charge monitoring. The low power consumption and low operating voltage of the PIC means that no special reservoir capacitors are needed to achieve this.

On power up, the previously saved remaining charge value is read for use. A reset button is used to set the state of charge following recharging.

George Mackiewicz is this month's winner of a $150 gift voucher from Jaycar & Altronics.

Calibrating the unit is relatively simple: enter the rated battery capacity into the software and trial run the vehicle until the battery is depleted. Note the readout, preferably using the analog output. This should correspond to about 10% charge remaining. Change the battery capacity to match where the desired "0%" (empty) reading is to occur.

The level of accuracy is adequate for the task and is reflected in the resolution; that is, 10% steps for the digital readout. It is possible to "tune" and calibrate to a much better accuracy but the complexity of adjustments will increase dramatically.

There is plenty of scope to increase accuracy by adding battery ageing and capacity reduction due to the number of cycles, charge ingress (eg, from regenerative braking or a solar charger) and additional Peukert factors. There is scope as well to experiment with functionality such as the voltmeter function and automatic detection of charge. Some points are commented in the source code.

Note that in order to avoid additional complexity with a user interface for setting the initial parameters, at least the nominal battery capacity must be entered in the source code before programming the PICAXE. The user may also want to adjust the battery capacity considering the "depth of discharge" intended to be used, rather than the nominal battery capacity.

Two types of display signals are provided. First, there is an analog line with a voltage proportional to remaining charge. This can drive a high-impedance display such as a LED panel meter or a LED Bar/Dot display (eg, LM3914), or even a moving coil meter. Analog displays will require a potentiometer to adjust full-scale voltage to whatever the display utilises. Typically, LED/LCD "Panel meters" have a 200mV input, whereas the analog output has a range from 0-4.5V.

The second display output is a BCD (4-bit) signal representing the 10's digit of percentage remaining. This is intended to drive a self-contained 7-segment display (HP 5082-7304). These digital lines could be changed by software modifications to provide four discrete LED drives showing 25% per LED.

An LM2575-ADJ switchmode regulator provides a 5V supply from the battery. The LM2575 can be used for 24V and 36V batteries and will work for 12V batteries if the low voltage cut-out is above about 11V. Note that the "standard" LM2575 is rated for 45V input, hence charging a 36V lithium battery at about 42V is within the limits.

For higher charge voltages or for a 48V battery, the LM2575HV should be used, as this chip is rated for 60V input. It is possible to substitute a linear regulator if the analog output is used to drive a meter rather than LEDs. This is possible due to the low current consumption of the current sensor and PICAXE micro (about 12mA @ 5V together).

The current is monitored by an ACS712-20 Hall Effect sensor which has an extremely low series resistance and provides isolation of the battery circuit from the measuring circuit. This chip has auto-zero and has a capacity of 20A. These chips are available via Aliexpress for about $14 for 10, including postage. There are also 5A and 30A versions, which could be used without circuit modifications.

Note that if the electric motor and associated controller are correctly designed, then the PWM current will be effectively smoothed by the motor. The result is that the current will have some ripple but should not exhibit large current pulses due to PWM. If a "dummy load" (eg, a globe) or a resistive load is used to operate or test this circuit, then PWM pulses will be evident and the average current may be read incorrectly. In this case, additional filtering (RC) will be required on the output of the ACS712.

The current sensor has a internal filter but uses an external capacitor at pin 6. In some cases, it may be necessary to adjust the filter to suit the PWM frequency. The filter capacitor value shown produces a cut-off frequency of about 900Hz. If the PWM frequency is below a few kilohertz, then a larger value may be needed. If additional filtering is used, it may be necessary to recalibrate the sensitivity in software.

The software consists of three 'tasks'. Task 0 performs the main current metering and display functions; Task 1 monitors the charge "Reset" button and Task 2 monitors the battery voltage to trigger saving of battery state of charge.

The operation of Task 0 is as follows. At power up, the software retrieves the last saved "remaining charge" from non-volatile memory and reads the current using an ADC input at pin 18 of the micro. The reading is converted to amps and a "Peukerts" factor is added if applicable and the value is saved.

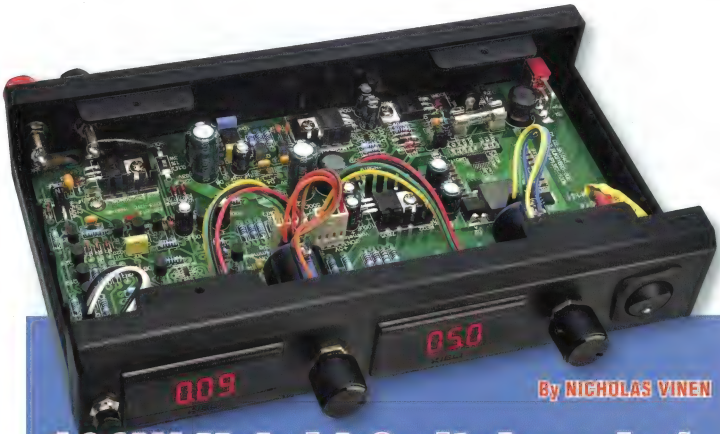
Note that only one Peukert current correction point is used since lithium batteries allegedly have very low Peukert exponents (~1.02). Additional current correction points for differing battery characteristics could be added if the target battery requires significant corrections.

The readings are repeated 10 times, with a delay of 100ms per loop, and averaged to form a 1-second value of current. Averaging is used to counter PWM ripple from the sensor. The current is then converted to "amp hours" or more precisely "microamp hours" which is used to obtain the required resolution of consumption. The "microAMp-hour" value is subtracted from the "remaining" (or charged) capacity.

The remaining capacity is displayed in analog form via the DAC output. The DAC resolution is 31 steps from 0V to about 4.5V. The reading is also converted to 1-digit BCD, which represents the 10's digit of a percentage, ie 10%, 20%, 30% etc up to 90%. This only provides nine steps and obviously has less resolution than the analog voltage with 31 steps. Following the display routines, the program loops and again reads the current.

As noted above, it is necessary to set the nominal battery size in the source code. This is done in about line 41 before programming the PICAXE. Please refer to the comments in the code. The software, *bat_meter_v7.bas*, is available for download from the SILICON CHIP website.

George Mackiewicz,
Vermont, Vic.



By NICHOLAS VINEN

100W Hybrid Switchmode/ Linear Bench Supply, Pt.2

Last month, we introduced our new 40V switchmode bench supply which can deliver up to 5A and fits into a compact rack-mount case with dual metering. This month, we describe the operation of the linear regulator circuit, discuss the PCB layout design and start the assembly by installing the parts on the PCB.

SINCE WE didn't finish describing the circuit last month, here's a quick refresher. The low-dropout (LDO) linear regulator determines the final output voltage and current, with the preceding switchmode section 'tracking' its output so that the input to the LDO is slightly higher than its output (by about 0.75V).

This gives the linear regulator sufficient 'headroom' to operate while keeping dissipation low – at 5A, the dissipation is around 5A x 0.75V = 3.75W which is manageable with a small heatsink. This arrangement also means that if the current limit is set to a high level and the output is shorted, the switchmode regulator's output quickly drops to a low level and so the overall dissipation is kept reasonable.

A couple of different approaches can be taken when designing a low-dropout linear regulator. One is to use a PNP transistor or P-channel Mosfet as the pass element and thus its base or gate is pulled towards ground to turn it on. The minimum drop-out voltage is simply the pass transistor's saturation voltage at full load current.

However the fact that the base/gate voltage has to be pulled lower to increase the output current and higher to reduce it complicates the feedback system, since this type of arrangement can't have any 'local feedback'. This is why monolithic LDO regulators often have quite specific requirements for the output capacitor value and ESR to ensure stable operation; they rely solely on global feedback and the phase shift from the output capacitor forms a critical parameter for correct operation.

The other option is to use an NPN transistor or N-channel Mosfet with

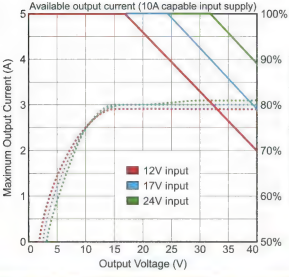


Fig.4: the circuit is capable of delivering 5A but this is limited at higher voltages by the power delivery capabilities of the DC supply and the 10A input limit. This graph shows how much current is available over the full output range for three common supply voltages. Note that the efficiency is best at lower output voltages. Note also that while the unit is capable of the indicated current, the switchmode section will get warm if operated at these limits for extended periods.

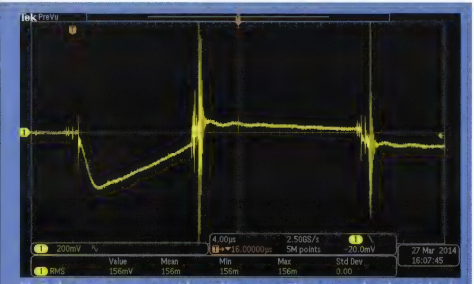


Fig.5: the output response with a 12V input, a 15V output and with a 1A load being rapidly connected and disconnected with no external output capacitor. The vertical scale is 200mV/div and the timebase is 4µs/div. As you can see, when the load current suddenly increases, the output drops but quickly recovers. There is a small amount of overshoot when the load is removed but it is well-controlled. The undershoot when the load is re-applied soon after is smaller than the first time as the switchmode section has not yet returned to idle operation.

its base/gate voltage driven from a 'boosted' supply rail somewhat above the main supply rail. In this circuit, we're using a Mosfet with a boosted supply that's around 10V above the output voltage. This allows us to vary the Mosfet's on-resistance from a very high value of many megohms when the output voltage is low and the load is light to a very low resistance of around 15mΩ when it's delivering full load current.

This arrangement gives superior regulation and filtering since it will inherently self-regulate to a certain extent. If the Mosfet's gate voltage is held constant, its source voltage (ie, the output) will be a certain amount lower than this and it will only vary over a small range (~1V), regardless of the drain voltage (ie, upstream supply).

Consider what happens if the output voltage (source terminal) drops and the gate voltage is constant. In this case, the Mosfet's gate-source potential increases and that turns the Mosfet on harder so that it conducts more current and thus pulls the output voltage up. Conversely, if the output voltage increases, the gate-source voltage drops and so the Mosfet conducts less current, thus reducing the output voltage.

While this mechanism is 'local' and therefore very fast, it isn't very accurate as the gate-source voltage varies somewhat with temperature and channel current. So there still needs to be a global negative feedback mechanism to give an accurately regulated DC output voltage. However, this feedback system is less critical to performance thanks to that inherent local feedback.

Also, because there is less phase shift in this arrangement, the feedback loop doesn't have to be as heavily compensated and this allows the global feedback to act more rapidly, responding more quickly to sudden changes in load impedance.

Design details

There are a few regulator ICs which operate in this manner but all the ones we could find have a fixed current limit threshold, set by a low-value resistor in the main current path. That makes it awkward to implement a wide-range adjustable current limit.

As a result, we built our own regulator circuit. This is obviously more complex than using an IC but the parts are cheap and commonly available whereas ultra-LDO regulator controller ICs are somewhat expensive and hard to get.

Fig.6 shows the circuit of this linear regulator section. The labels at the edges match up to the labels on Fig.3, published in Pt.1 last month, to show the connections between the two circuit sections. Taken together, these form the complete circuit of the bench supply.

The incoming supply rail (VIN) comes from the output of the switchmode regulator and its ripple filter, described last month. Mosfet Q23 controls current flow from this supply to the output (VOUT+), as described above, with its gate voltage typically 2V above the output voltage.

The regulator circuit is somewhat similar to that of an audio amplifier due to the need for accurate and fast-acting negative feedback. If you compare the two, you will find that there are broad similarities but subtle differences. The most obvious difference is that there are two differential input pairs, one to control the output voltage and the other enforce the current limit. These are based around PNP

Features & Specifications

Size & weight: 209 x 43 x 162mm, 400g
Input supply: 12-24V at up to 10A
Input under-voltage lockout: 11.3V
Output range: 0-40V at up to 5A (see Fig.4)
Output power: 100W+, depending on input supply voltage and current
Output ripple & noise: typically <5mV RMS @ 1A, ~1mV RMS at light load
Output capacitance: 2.2µF internal, handles any external capacitive load
Load regulation: <10mV for a 1A load step (measured at PCB terminals)
Line regulation: <5mV, 12-24V
Transient response: <500mV undershoot/overshoot for a 1A load step, recovery in ~10µs (no external capacitor) (see Fig.5)
Current limit response time: <150µs (short circuit @ 40V); <2ms to resume voltage regulation (depending on current limit)
Efficiency: ~70-80% (see Fig.4)
Voltmeter: resolution 0.1V, accuracy ±0.1V
Ammeter: resolution 10mA, accuracy ±10mA
Protection: fuse, cycle-by-cycle input current limiting, output current and voltage limiting
Current limit: continuously adjustable 0-5A, typically stable within ±1mA
Other features: view current limit, load switch

transistor pairs Q14/Q15 and Q9/Q10 respectively.

For accurate DC control, we need the base-emitter voltages of these transistor pairs to be fairly accurately matched (or rather, for the difference between them to remain constant) but this depends on temperature. So differential heating or cooling of these transistors due to air currents and so on, even of a fraction of a degree, can affect operation. As such, these transistor pairs are thermally bonded so that they remain at the same temperature.

This can be achieved one of two ways: either by using two transistors in a single package or by bonding two separate transistors with thermally conductive paste. The PCB is designed for either approach but thermal tracking is better when the two transistors are in a single package so we have used the BCM856DS dual-matched transistors for our prototypes. We suggest you do the same.

These are rather neat devices, being equivalent to two BC556s in a 6-pin surface-mount package. The current gain (hFE/beta) and base-emitter voltages are matched to within 10% and 2mV respectively. They are quite affordable and available in three different packages; we are using the largest one since it is easier to solder.

To understand the operation of the regulator as a whole, start by considering voltage-monitoring transistor pair Q14 & Q15. The two emitters are fed with a constant current of about 1mA by PNP transistor Q13, with this current set by the 680Ω resistor at its emitter. A bias voltage fed to Q13's base via a 2.2kΩ resistor from Q18 acts to keep around 0.6V across the 680Ω resistor.

This differential pair has 47Ω 'emitter degeneration' resistors to reduce the overall gain somewhat and improve linearity, which aids stability. The collector currents are kept more or less equal by a current mirror consisting of NPN transistors Q16 & Q17. This keeps the circuit operating consistently despite large variations in supply voltage as the output voltage varies.

Q14's base is tied to the negative output terminal (ie, effectively ground) via a 22Ω resistor, while Q15's base goes to the output feedback divider (shown in Fig.3 last month) via "OV-feedback". This is a divided-down version of the output voltage, as set by VR1, the voltage adjustment pot.

When the regulator's output voltage increases, the voltage at Q15's base also increases, reducing the current through Q15. Since the collector currents are mirrored, this means that more of the 1mA total emitter current must flow from Q14 to D7 to maintain an equal current through Q16 and Q17.

D7 feeds the base of Q25 so as this current flow increases, its collector voltage drops, reducing the drive voltage to the NPN/PNP emitter-follower push-pull pair of Q21 & Q22. This in turn pulls down Q23's gate, reducing the output voltage until it is back where it should be and the bases of Q14 & Q15 are then at the same voltage.

Conversely, if the output voltage drops, the reverse occurs and the voltage at Q23's base increases to compensate.

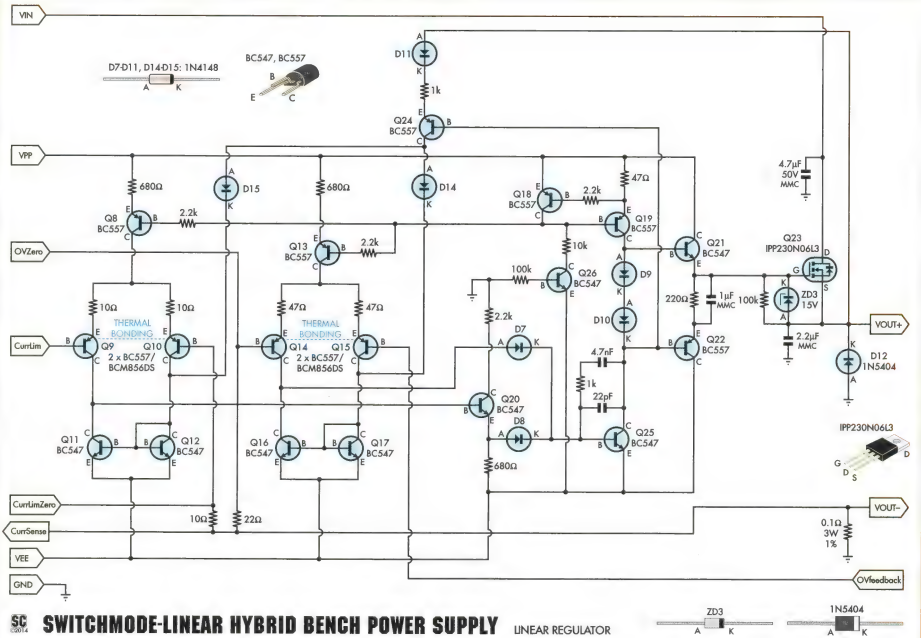
Q25 has a 22pF Miller capacitor to reduce the AC open loop gain at high frequencies, to keep the feedback loop stable, otherwise Q23's gate voltage would not settle down. In parallel with this Miller capacitor is a 4.7nF capacitor with a series 1kΩ resistor. This improves stability when a high-value capacitor is connected to the output of the supply, avoiding excessive voltage overshoot. It also helps stabilise the voltage during current limiting.

The 2.2µF output capacitor is also important for stability and this and the Miller capacitor component values have been chosen as a compromise between stability, fast transient response and a low output capacitance so that the supply can more closely approximate an ideal current source.

Q25's collector load is another constant current source, this time providing around 12.5mA. It's controlled by Q19 which (like Q8 & Q13) is biased by Q18, in turn biased by a 10kΩ resistor to the negative supply via Q26. The 47Ω resistor sets the current through Q19 to 0.6V ÷ 47Ω = ~12.5mA. This value was chosen based on the 625mW dissipation limit for Q25, given the maximum possible voltage across it of around 46V, when the output is at 40V.

Diodes D9 & D10, in series with Q25's collector, bias the base-emitter junctions of buffer transistors Q21 & Q22 so that they are both slightly conducting all the time. This speeds up the 'hand-off' between them as the output switches from slewing positive to negative and vice versa.

The quiescent current through this pair is limited by a 220Ω resistor which is bypassed with a 1µF capacitor so that Q23's gate can be quickly discharged by Q22. Note that the relatively high 12.5mA through this stage is required so that Q23's gate can be



SC SWITCHMODE-LINEAR HYBRID BENCH POWER SUPPLY

LINEAR REGULATOR

Fig.6: the linear section of the circuit diagram. This matches up with the switchmode section published last month (Fig.3) via the labelled inputs and outputs. This is essentially a self-contained ultra-low-dropout linear regulator with adjustable current limiting. Q14 & Q15 compare the feedback voltage to a ground reference and regulate the output voltage while Q9 & Q10 enforce the current limit by comparing it against the voltage across the 0.1Ω shunt. There is provision to zero (trim) the output voltage and current limit via OVZero and CurrLimZero respectively.

Parts List

1 double-sided PCB, code 18104141, 198 x 95mm
1 half-rack plastic instrument case with two integrated LED panel meters and SPST rocker switch (available from Altronics)
2 M205 fuseholder clips
1 10A M205 fast-blow fuse (F1)
1 10µH 15.5A 5MHz shielded SMD inductor, 14x14mm (L1) (SCIHP1367-100M; Digi-Key Cat 595-1400-1-ND)
2 3.3µH 5.6A bobbin inductors (L2,L3) (RLB1314-3R3ML; element14 Cat 2333682, Digi-Key Cat RLB1314-3R3ML-ND)
1 PCB-mount DC socket (CON1)
1 pair red & black chassis-mount binding posts (CON2)
2 4-way polarised headers & matching header plugs with crimp pins (CON3, CON4)
2 3-way polarised headers & matching header plugs with crimp pins (CON5, CON6)
1 SPDT PCB-mount right-angle toggle switch (S1) (Altronics S1320 or similar)
1 small chassis-mount SPDT momentary pushbutton switch (S2) (eg, Altronics S1391)
2 3-pin headers (LK1,S2)
1 2-pin header (LK2)
2 jumper shunts (LK1,LK2)
1 3-pin female header plug or cable with suitable plug (for S2)
2 10kΩ linear 10-turn panel-mount potentiometers (VR1-VR2) (eg, Rockby 41645***, element14 1144798/1612609/1386483 etc) **OR**
2 10kΩ linear chassis-mount standard potentiometers
4 500Ω mini horizontal trimpots (VR3-VR6; VR7 optional)
1 20kΩ mini sealed horizontal trimpot (VR8, optional)
2 knobs to suit VR1 & VR2
1 ferrite bead (FB3)
3 6073B-type TO-220 "Micro-U" heatsinks
4 M3 x 6mm machine screws and nuts
1 150mm length rainbow cable or assorted light-duty hookup wires
1 100mm length tinned copper wire
1 500mm length extra-heavy duty hookup wire
2 6.8mm female spade crimp connectors to suit extra-heavy duty wire
4 No.4 x 6mm self-tapping screws
2 M3 x 5mm black machine screws
*** Limited stock available

Semiconductors

1 LM5118MH(X) buck/boost switchmode regulator IC (IC1) (element14 Cat 1606457, Digi-Key Cat LM5118MHX/NOPBCT-ND)
1 7555 CMOS timer IC (IC2)
1 LM2940CT-12 12V 1A low-dropout regulator (REG1)
1 7805 +5V 1A regulator (REG2)
1 79L05 -5V 100mA regulator (REG3) (Altronics Z0466)
1 LM285Z-2.5 voltage reference (REG4) (Jaycar ZV1626)
1 IRF1405 or IPP230N06L3 N-channel Mosfet (Q1)
2 BUK9Y6R0-60E 60V 100A N-channel SMD logic-level Mosfets (Q2,Q3) (Digi-Key Cat. 568-10984-1-ND)
3 BCM856DS dual PNP SMD transistors (element14 Cat 1829188, Digi-Key Cat 568-6834-1-ND) OR
6 BC557 100mA PNP transistors (Q4,Q5,Q9,Q10,Q14,Q15)
1 BC337 NPN transistor (Q6)
1 BC327 PNP transistor (Q7)
6 BC557 100mA PNP transistors (Q8,Q13,Q18,Q19,Q22,Q24)
8 BC547 100mA NPN transistors (Q11,Q12,Q16,Q17,Q20,Q21, Q25,Q26)
1 IPP230N06L3 N-channel Mosfet (Q23)
2 SK1545 45V 15A SMD Schottky diodes (D1,D2) (Digi-Key Cat. SK1545-TPCT-ND)
13 1N4148 signal diodes (D3-D11,D13-D15,D18)
3 1N5819 1A Schottky diodes (D16,D17,D19)
1 1N5404 3A diode (D12)
3 15V 1W zener diodes (ZD1,ZD3,ZD8)
4 27V 1W zener diodes (ZD2,ZD5-ZD7)
1 4.7V 0.4W or 1W zener diode (ZD9)

Capacitors

2 220µF 50V/63V low-ESR electrolytics
8 100µF 25V electrolytics
2 47µF 50V/63V low-ESR electrolytics
9 10µF 25V X5R SMD ceramic, 3216 (imperial 1206) or 2012 (imperial 0805) package
10 4.7µF 50V X5R SMD ceramic, 3216 (imperial 1206) or 2012 (imperial 0805) package
1 2.2µF 50V MMC*
3 1µF 50V MMC*
1 1µF 50V X5R SMD ceramic**
2 100nF 50V ceramic disc or MMC*
4 100nF 50V X7R SMD ceramic**
1 10nF 50V MKT or MMC*
1 10nF 50V X7R SMD ceramic**
1 4.7nF 63V MKT
1 4.7nF 50V X7R SMD ceramic**
1 2.2nF 63V MKT
1 2.2nF 50V X7R SMD ceramic**
1 330pF 50V C0G/NP0 SMD ceramic**
3 100pF 50V ceramic disc
1 22pF 50V ceramic disc

Resistors (0.25W, 1% unless stated)

2 10MΩ	7 2.2kΩ
1 1MΩ	1 1.8kΩ
1 910kΩ	2 1kΩ
5 100kΩ	2 820Ω
1 82kΩ 1% SMD**	5 680Ω
1 15kΩ 1% SMD**	2 470Ω
4 10kΩ	1 220Ω
2 10kΩ 1% SMD**	3 47Ω
1 9.1kΩ	1 22Ω
2 3.3kΩ	5 10Ω

1 10Ω 1% SMD**
1 0.1Ω 1% 3W SMD 6432 (2512 imperial) (element14 Cat 1435952, Digi-Key Cat CRA2512-FZ-R100ELFCT-ND) **OR**
1 0.1Ω 1% 3W through-hole resistor (Welwyn OAR-310F or similar)
1 15mΩ 0.75W or 1W SMD 3216 (1206 imperial) (element14 Cat. 1887165, Digi-Key Cat. MCS1632R015FERCT-ND)

** Monolithic Multi-layer Ceramic*
*** These SMD passive components can be in either 1608 (imperial 0603) or 2012 (imperial 0805) packages*

Table 1: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
2	10MΩ	brown black blue brown	brown black black green brown
1	1MΩ	brown black green brown	brown black black yellow brown
1	910kΩ	white brown yellow brown	white brown black orange brown
5	100kΩ	brown black yellow brown	brown black black orange brown
4	10kΩ	brown black orange brown	brown black black red brown
1	9.1kΩ	white brown red brown	white brown black brown brown
2	3.3kΩ	orange orange red brown	orange orange black brown brown
7	2.2kΩ	red red red brown	red red black brown brown
1	1.8kΩ	brown grey red brown	brown grey black brown brown
2	1kΩ	brown black red brown	brown black black brown brown
2	820Ω	grey red brown brown	grey red black black brown
5	680Ω	blue grey brown brown	blue grey black black brown
2	470Ω	yellow violet brown brown	yellow violet black black brown
1	220Ω	red red brown brown	red red black black brown
3	47Ω	yellow violet black brown	yellow violet black gold brown
1	22Ω	red red black brown	red red black gold brown
5	10Ω	brown black black brown	brown black black gold brown
1	0.1Ω	not applicable	not applicable

quickly charged when the output is slewing in the positive direction, eg, when recovering from a brief short circuit.

Zener diode ZD3 clamps Q23's gate voltage to no more than 15V above its source. Normally, the supply rails guarantee this but under some conditions it could be exceeded, hence the zener clamp.

Q23's gate voltage is prevented from going below the output voltage by Q24. As the gate goes negative, Q24's base is pulled below its emitter and thus delivers current to the collectors of Q17 & Q12 via diodes D14 & D15. This forces the drive to Q25's base to be reduced, thus preventing Q23's gate from dropping any further. The zener will also do this job however the advantage of including Q24 is that it also acts to clamp Q25's collector voltage, giving much faster recovery from current limiting.

Q26 ensures a clean start-up when power is first applied. It prevents the bias current for Q8, Q13 & Q19 from flowing to VEE via the 10kΩ resistor until the VEE negative rail has dropped below about -1V. Without this bias, Q19 remains off and so Q25's collector voltage remains low until the supplies stabilise. The 100kΩ resistor across ZD3 keeps Q23's gate discharged during this time, so it remains off and the output voltage stays low.

Note that we want to be sure that when OVFeedback is connected to VOUT+ via a low resistance (ie, voltage adjustment pot VR1 is at minimum), the output voltage is zero. This depends on how accurately Q14 & Q15 are matched and also on the tolerances of VR1.

These error sources are trimmed out by injecting a small current from "OVZero" into the base of Q14 (from trimpot VR4, in Fig.3 last month). This develops a maximum of a few millivolts across the 22Ω resistor and allows the output to be nudged one way or the other.

Current limiting & regulation

The current regulation mechanism operates similarly to the voltage feedback described above. Differential input pair Q9 & Q10 is configured identically to Q14 & Q14 except that 10Ω emitter degeneration resistors are used rather than the 47Ω. That's because the voltage levels applied to this differential pair are much lower (500mV maximum).

Also, rather than the output current from this differential front-end driving Q25 directly, it's amplified by Q20. This is required because if the output current exceeds the set level by 1mA (for example), the voltage difference between the bases of Q9 & Q10 is just 0.1mV. However, we want the output voltage to drop rapidly as soon as the current limit is exceeded by even by a small amount and so Q20 provides additional current gain of around 250 times.

Q9's base is the non-inverting input of the pair and this is connected to VR2's wiper. This is the current limit adjustment potentiometer ("CurrLim") and it supplies a 0-500mV signal to set the current limit to between 0 and 5A. Q10's base is connected to the top of the 0.1Ω current-sense resistor via an additional 10Ω resistor. This allows a small current injection from the "CurrLimZero" input to pull this a few millivolts one way or the other, to cancel out the differences in the base-emitter voltages of Q9 & Q10.

Thus, if the voltage across the sense resistor exceeds the voltage from VR2's wiper, current flow from Q9 to Q20's base increases and thus D8 becomes forward-biased. This pulls Q25's collector down and thus reduces the output voltage until the current flow stabilises at the set level.

Q20 is linearised by a 680Ω emitter resistor for a more progressive action (no additional Miller capacitor is needed). A 2.2kΩ collector resistor (from ground) limits the current delivered to Q25 under a hard short circuit condition and thus limits the dissipation in Q25. Diode D12 protects the circuit in case an external load pulls the output terminal negative.

Remaining circuitry

The regulator's positive rail is labelled VPP and comes from the charge pump described last month (see Fig.3). This tracks VIN and is generally boosted to be 10V higher. VEE is a regulated -5V rail, derived from the same charge

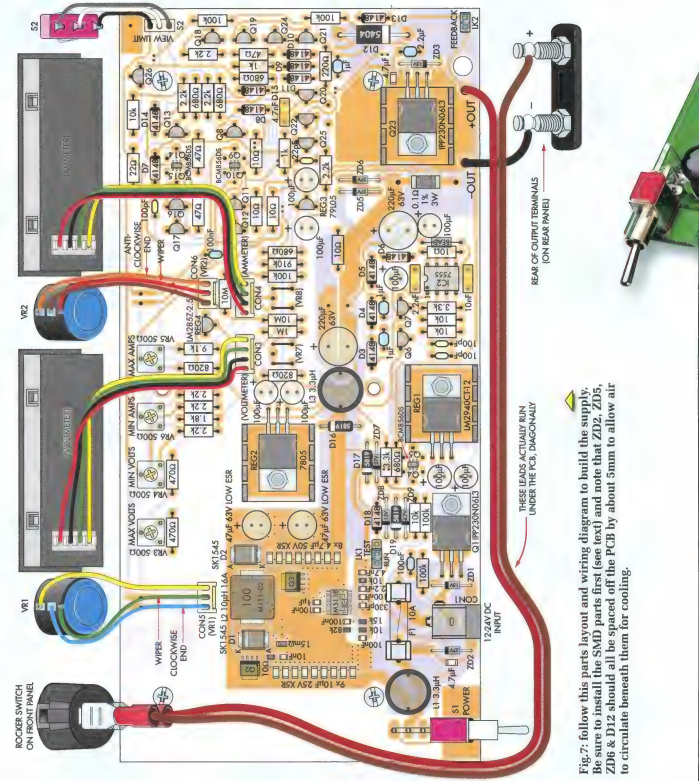
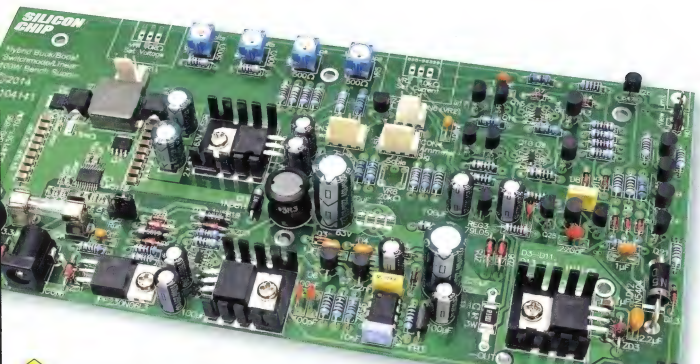


Fig.7: follow this parts layout and wiring diagram to build the supply. Be sure to install the SMD parts first (see text) and note that ZD2, ZD5, ZD6 & D12 should all be spaced off the PCB by about 5mm to allow air to circulate beneath them for cooling.

pump. These supply rails are "wider" than the input supply (VIN) and ensure that Q23's gate can vary over a wide enough range (approximately 0-43V) to control the output over the full range of 0-40V.

There are a couple of aspects of this circuit which are not obvious at first glance. The top end of the 0.1Ω current-sense resistor is connected both to "VOUT-" and "CurrSense". The former is for return current to flow from the load while the latter goes to the ammeter divider circuit. This sense resistor can dissipate up to 2.5W at 5A; its value was chosen as a compromise between keeping the dissipation reasonable and giving enough of a voltage swing for the current-limiting circuitry to operate quickly and accurately.

In addition, the non-inverting input



This view shows the completed PCB, ready for installation in the case. Follow the procedure described in the text to solder in the SMD parts.

for voltage regulation (Q14's base) is connected to the top of this resistor (ie, CurrSense) rather than to ground as you might expect. This is because we don't want the output voltage to drop as the load current increases due to the increase in voltage across the current sense resistor.

This connection for Q14, in combination with the fact that the output divider's -2.5V reference is also connected to the top of this sense resistor (via Vout-; see Fig.3 last month), means that the voltage as set by VR1 is actually VOUT+ – VOUT-. As a result, when VOUT- increases, so must VOUT+ due to the negative feedback action.

Minor changes

Since publishing the main circuit diagram last month, we have made a few minor changes to the circuit. First, we added a 100µF bypass capacitor at the input of REG2, as the latter was moved away from REG1 and its 100µF output filter capacitor to aid heat dissipation.

We also increased the value of the 2.2MΩ resistor (near VR8) to 10MΩ and reduced the associated 1kΩ resistor to 680Ω, so that the ammeter reads zero when there is no current flow.

In addition, the 680Ω resistor connected to VR5 has been changed to 820Ω to ensure that the maximum current can be set to 5A.

Finally, the 1kΩ resistor at the ground end of VR7 has been reduced to 820Ω, although if you link out VR7 as suggested, either value will work.

Building it

Despite the circuit complexity, the assembly is quite straightforward. All the parts are mounted on a PCB coded 18104141 and measuring 198 x 95mm. Fig.7 shows the parts layout and external wiring details.

It's easiest to fit all the surface-mount (SMD) parts on the PCB first, starting with IC1. Begin by removing it from its packaging and locating the pin 1 dot (which isn't all that obvious).

If using hot-air station or a reflow oven, it's simply a matter of sparingly applying fresh solder paste to the pins and central pad, placing the IC with the dot at lower-left and then heating the device until the joints are formed. Alternatively, provided you have a temperature-controlled soldering iron with a fine bit, you can certainly do it by hand.

The procedure for hand-soldering IC1 is as follows. First, it's a good idea to first place a blob of flux gel on the central pad. This helps hold the IC in place during soldering and will also come in handy when it's time to solder the thermal pad. That done, put a very small amount of solder on one of the pads, check that its orientation is correct, then heat this solder and slide the IC into place.

Now check that all the pins are correctly aligned with their pads using a magnifying glass. Each pin should be on top of its associated pad and not protruding over the side. Unless you're very lucky, it won't be right the first time in which case you need to reheat the single soldered pad and give the IC a gentle nudge in the right direction. Repeat this procedure until you're happy with the placement, then solder the diagonally opposite pin and re-check the orientation.

Having tacked it down, you now have several possibilities for soldering the remaining pins. You can solder two or more pins at a time by placing

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
2.2µF	2.2µF	2u2	225
1µF	1µF	1u0	105
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
4.7nF	.0047µF	4n7	472
2.2nF	.0022µF	2n2	222
100pF	NA	100p	101
22pF	NA	22p	22

The PCB fits neatly inside this standard instrument case which comes complete with 3.5-digit LED readouts for simultaneous voltage and current display. The final assembly details are in Pt.3 next month (prototype PCB shown).

a standard chisel/conical tip between a pair of pins and feeding a small amount of solder in (pre-fluxing the pins helps) or you can run flux down both sides of the IC and then drag solder all the pins in one go using a hoof or mini-wave tip (this can also be done with standard tips but not as easily). In either case, using a high-quality flux paste makes the process a lot easier.

Don't worry if any or even all the pins are bridged after soldering; it's just a matter of applying some more flux paste, placing some solder wick over the bridge and then heating it until it 'sucks up' the excess solder. Just be careful not to pull on the wick or otherwise apply force until the solder has melted or you could damage the IC pins or the board.

Once the chip is in place, flip the board over and apply some liquid flux or flux gel to the three vias under IC1. Now melt some solder into these holes; there is an exposed pad surrounding them to make it flow better. The combination of capillary effect and flux on both sides of the board should cause the solder to flow through and form a joint between the IC and pad on the other side. You can confirm this is the case by touching the IC after doing this; it should be quite hot due to the solder that's adhered to its thermal pad.

Finally, clean off any flux residue or other contaminants using a good solvent and then carefully examine the joints using a magnifying glass and lamp to ensure that every pin has been soldered to its pad and no bridges remain.

Note that if you ever have to remove this IC, it's easy to do using a hot-air gun (which can be bought quite cheaply). It's virtually impossible to do using any other method, without damaging the board.

SMD Mosfets

These are next on the list. Again, you can use solder paste and hot air/reflow however these can also be soldered using a regular iron. Put some flux on the large PCB pad for the tab and then flow a small amount of solder onto it. Ensure this forms a thin, even layer on the pad; if not, clean off the excess using solder wick.

Now do the same to the underside of the Mosfet tab itself; you will probably have to place it in a mini vice or some other clamp while doing so.

Next, spread some flux paste onto the tinned PCB pad, then put a small amount of solder onto one of the four smaller mounting pads on the PCB. It's easiest to start with the topmost (Q2) or right-most (Q3) pad (ie, the Mosfet gates) as these have the least thermal mass.

As with IC1, heat this solder and slide the Mosfet into place, then check that its tab and remaining pins are properly centred on their pads. You can now apply a little flux along the edge of the large tab and heat it with your soldering iron until the layers of solder on both melt and merge.

That done, it's just a matter of letting it cool a bit, soldering the three remaining pins, then touching up the gate joint (ie, the first small pin you soldered) using a bit of extra flux.

You can now use a similar procedure to fit inductor L1, ie, tin the underside of its leads, tin the PCB pads, add flux to both, then flow them together. Press down gently on the inductor while soldering the second pad and then re-flow the first one to ensure it's right down on the board. Note that it might be necessary to add more solder to the initial pad, to form a good joint. That's

the easiest method we've found to solder such a large SMD component.

While doing this, you will need to hold it with tweezers or similar as it gets hot! Use this same technique to fit diodes D1 & D2 but be careful with their orientation; their cathode stripes face in opposite directions.

You can now fit all the remaining SMD capacitors and resistors. In each case, it's just a matter of placing solder on one of the pads, sliding the part in, waiting for the joint to cool and then soldering the other side. Be careful though because it's quite easy to get solder to flow onto the part but not the PCB pad; use plenty of flux, clean off the residue and inspect the joints carefully under magnification.

Note that the resistors will be labelled with their value (eg, 15kΩ = 153, 10Ω = 100). On the other hand, the ceramic capacitors are not labelled and you will have to check the value on the packaging before removing them. Note also that there are some SMD components away from the switchmode section. These are the two additional 4.7μF ceramic capacitors near lower-left and lower-right and the 0.1Ω shunt near the negative output terminal. You can use a through-hole shunt instead of an SMD type, if you can get one with that will fit and has the correct rating.

Now is also a good time to solder in the three BCM856DS dual transistors (assuming you are using these, as recommended). Their pin layout is symmetrical so orientation doesn't matter. You may be able to solder the pins individually, then clean up any bridges with flux paste and solder wick. In fact, we like to add some flux and apply solder wick anyway as reflowing the joints in this manner gives a more consistent and reliable result.

Through-hole parts

With the SMDs out of the way, the

PCB Design & Layout

The main part of the article describes how the circuit works but that isn't the end of the story. Let's take a quick look at a couple of the trickier aspects of the PCB design.

The most obvious place where layout is critical is around the switchmode regulator, ie, IC1, D1, D2, Q2, Q3 and L1. We've purposefully chosen small components here, while also taking into account ease of soldering. The rationale behind this is that by keeping the components small, the distance through which high switching currents must flow is kept to a minimum and thus the resistance and parasitic inductance of the short, wide PCB tracks used is kept to a minimum. The current flowing through these components thus also stays close to the PCB's ground plane.

This ground plane acts as a shorted turn for the various parasitic inductors (transformers) formed by loops in the circuit but this isn't perfect – it is on the other side of the PCB (~1.5mm away) and does not have zero resistance. So it's good practice to keep those loops as small as possible.

The layout of this switchmode section is based on the demonstration board for the LM5118 IC*. This is a rather clever scheme whereby the current runs around the edge, from the input at lower left up to the top, then across to the right and then down to lower-right. The central area is a large power groundplane to which the IC is connected and there are dozens of vias connecting this to the underside of the PCB where the groundplane covers nearly 100% of the area under the current-carrying components.

The idea behind this is that while current flows in a clockwise direction around this section, the return current flowing through ground goes in an anti-clockwise direction around the groundplane. This is because current follows the path of least impedance (not just resistance) and this is true when the parasitic inductance is minimised, ie, when the return current flows directly underneath the main current path.**

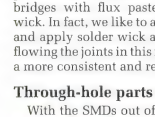
There is a separate analog ground plane below pins 1-10 of the IC (ie on the underside), above which the analog components are mounted (eg, compensation and feedback networks). The two groundplanes are joined under the IC. This keeps the switching noise out of the analog components.

The LM5118 has a large pad on its underside which is soldered to the PCB to provide heatsinking for the IC. The large copper area it's connected to helps draw heat away, too. Since constructors won't necessarily have a hot air or reflow station to solder the IC, we have placed three large vias through this pad and onto the bottom side, so that solder can be flowed through to this pad from underneath.

Finally, a note on the layout of the analog section. The ground return paths for the two panel meters have been brought back to the earth plane separately from other tracks so that the relatively high current flow (250-300mA) does not create ground voltage shifts to upset the meter readings or other circuitry. After all, the lowest digit on each meter has a resolution of just 0.1mV.

** See Texas Instruments application note AN-1819 at www.ti.com/lit/ug/snva334b/snva334b.pdf*

*** Some good information on current flows in double-sided PCBs can be found here: www.analog.com/library/analogdialogue/archives/41-06/ground_bounce.html*



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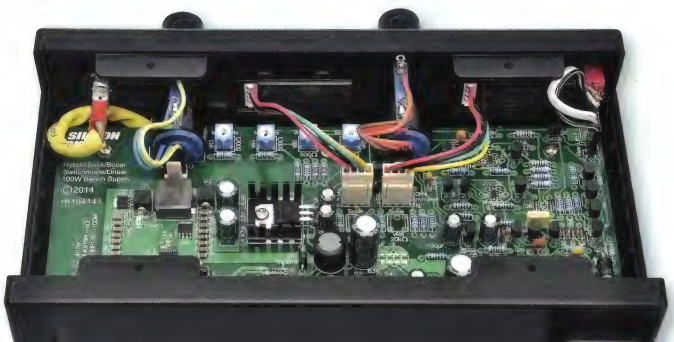


Another view inside the case, this time from the rear. The rear panel carries the power switch (S1), a hole to access the DC socket and the two output terminals (note: prototype PCB shown).

next job is to fit the passive through-hole components, starting with the 1N4148 diodes. Note that these do not all have the same orientation, so check the layout diagram (Fig.6) carefully. Follow with the resistors (check the values with a DMM if unsure) and then the medium-sized diodes such as the zeners and 1N5819s, again taking care with the orientation.

Leave 27V zener diodes ZD2, ZD5 & ZD6 out for now. Diode D12 (1N5404) should also be left out at this stage.

Now solder IC2 in place (don't use a socket), making sure that its notch or dot faces towards the top. Follow with ferrite bead FB3 (FB1 & FB2 were removed from the design). If you have a plain bead without leads, run a component lead off-cut through it.

The next job is to fit Q1. First, bend its leads down through 90° about 6mm down from the tab, then feed them through and fasten its tab down using an M3 x 6mm machine screw and nut. Solder and trim the leads, then install all the ceramic capacitors, including the multi-layer types, followed by the MKT capacitors.

That done, fit the zener diodes you left out earlier (ZD2, ZD5 & ZD6) but space these off the board by about 5mm to allow the air to circulate beneath them for cooling (they get hot if they conduct a significant amount of current). Next come the trimpots; remember that you probably don't need to fit VR7 & VR8 but if you do, VR8 should be the 20kΩ pot. If you aren't fitting them, each should have two wire links soldered in its place where shown.

You can now install the pin headers for LK1, LK2 and S2, followed by the two fuse clips. Check that these have the retaining lugs on the outside or the fuse will not fit and make sure they are fully inserted before soldering.

Next on the list are all the TO-92 devices, ie, the small signal transistors plus REG3 and REG4. Check their markings to ensure each one goes in the right place and bend the leads with small pliers if necessary, so that they fit the PCB pad layout. Note that if you are not using the BCM856DS chips, you will also need to install BC556s for Q4, Q5, Q9, Q10, Q14 & Q15. Be sure to smear thermal paste on the faces of these transistors and push each pair together so that they are in close contact.

The remaining diode (D12) can go in. It too should be spaced off the board by about 5mm. Follow this with the smaller electrolytic capacitors (47µF & 100µF), all of which are inserted with the positive (longer) lead towards the top of the board. The two bobbin inductors (L2 & L3) and the DC socket (CON1) can then go in. Be sure to push the latter all the way down onto the PCB before soldering.

Now for the heatsinked TO-220 devices, ie, REG1, REG2 and Q23. Don't get these mixed up; they are installed in the same manner as Q1 except that you will need to slide the heatsink under the device package before fastening each assembly down using an M3 x 6mm machine screw and nut. If you like, you can smear some heatsink paste on each device tab before its fastened down, although this isn't strictly required.

Finally, complete the PCB assembly by fitting the power switch (S1), polarised connectors (CON3-CON6) and the two 220µF electrolytic capacitors. If you're using a through-hole shunt, don't forget to install that too.

Next month

That's all we have space for this month. In the final article next month, we'll run through the test procedure and the trim adjustments, describe how to build it into the case and give some tips on using it. SC

GertDuino: when Raspberry Pi & Arduino join forces

By Nicholas Vinen

Get the best of both worlds with this Arduino board which plugs straight into the Raspberry Pi. It can be used as I/O expansion for the Raspberry Pi or as a standalone embedded board.

The Raspberry Pi is a powerful embedded platform (see our article in the May 2013 issue) but there are some difficulties interfacing it with other circuitry.

For a start, all its I/Os use 3.3V signalling while many other devices (such as those designed to interoperate with Arduino) may use 5V signalling. The Raspberry Pi could be damaged if the two are connected or the set-up may simply fail to work.

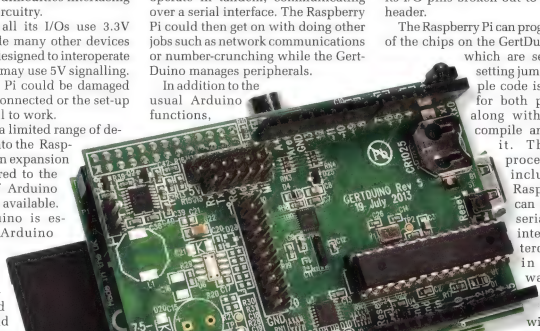
There's also a limited range of devices to plug into the Raspberry Pi's 26-pin expansion header compared to the large range of Arduino 'shield' boards available.

The GertDuino is essentially an Arduino Uno which plugs into the Raspberry Pi. It can then accept standard Arduino shield boards and can also off-load some processing from Raspberry Pi to one or both of its 8-bit processors.

There are two ways you can use the GertDuino. One is with the Raspberry Pi as an Arduino development platform simply to program the GertDuino. It can then be unplugged from the Raspberry Pi to operate independently.

The other option is to consider the GertDuino as a 'daughterboard' for the Raspberry Pi, so that it acts as an interface to external circuitry, possibly including one or more "shields". The Raspberry Pi and GertDuino can then operate in tandem, communicating over a serial interface. The Raspberry Pi could then get on with doing other jobs such as network communications or number-crunching while the GertDuino manages peripherals.

In addition to the usual Arduino functions,



the GertDuino has six on-board user-controllable LEDs and two general purpose pushbuttons. It also has a real-time clock with 32.768kHz watch crystal and battery back-up options, plus an infrared (IRDA/remote control) receiver and RS-232 level shifter.

The infrared interface and real-time clock are managed by the secondary processor. This is an ATmega48, similar to the main ATmega328 but with less RAM and flash. The mega48 has its I/O pins broken out to a separate header.

The Raspberry Pi can program either of the chips on the GertDuino board, which are selected by setting jumpers. Sample code is provided for both processors along with steps to compile and upload it. The three processors (ie, including the Raspberry Pi) can have their serial/SPI/I²C interfaces interconnected in various ways using jumper wires, with various example set-ups shown in the manual.

The GertDuino is available exclusively in Australia from element14 (au.element14.com, Cat No 2344460) for $32+GST.

You can also get a Raspberry Pi from element14 if you don't already have one; the Model B version now has 512MB RAM (Cat No 2191863, $38+GST) and is available with a plastic case (Cat No 2217158, $45.70+GST). There are other options too, such as a package including an SD card pre-loaded with software.

Deluxe Fan Speed Controller

By John Clarke

- Full Range: slow to maximum speed control . . .
- Suits ceiling or plug-in fans . . .
- No mysterious fan noises in the night . . .
- No AM radio interference . . .

Got a ceiling fan or pedestal fan? With limited speed settings they are often too fast or two slow. This non-switched controller gives you continuous speed control and as a bonus, it produces no radio interference or motor noise. It can also be used as a dimmer for desk and reading lamps up to 60W.

Ceiling fans usually offer just three switched speed settings: too fast, fast and not slow enough. The fast settings are probably OK during the day but even the slow setting may be too fast at night when you just want the fan to provide a gentle air movement, while you're trying to get to sleep.

So we decided to produce a controller which gives a wide range of speeds, from the maximum down to quite low, to give just the faintest of breezes.

But we decided not take the obvious approach of using a phase-controlled Triac to produce the speed control because they can cause considerable interference to AM radio reception, particularly in those areas where signals are weak.

Instead, our controller is based on a high-voltage Mosfet, which is effectively a variable resistor connected in series with the fan motor. For high fan speeds, the Mosfet resistance is low and for lower speeds, the Mosfet resistance is higher.

And while we have only mentioned ceiling fans up to this point, it can also be used with pedestal or table fans. You simply plug the fan into a switched mains socket on the controller's case lid, while the controller plugs into the mains via an IEC mains lead.

If you have a ceiling fan, it may need to be wired permanently (by a licensed electrician).

Because the speed control element is essentially a variable resistor, it will not be very efficient in electrical terms and that means it will dissipate some heat. But considering that most fans will draw only up to about 60W at full speed and less as speed is reduced, the dissipation can be

Features

- Full control of motor speed from stopped to maximum
- For 230VAC shaded pole and capaitor run motors
- Over-current limiting
- Over-temperature cut out
- Quiet operation
- Fused circuit
- Rugged case

managed by using a diecast box and finned heatsink.

We don't need to dissipate anywhere near 60W because at full speed the dissipation in the controller is quite small. It's at lower speeds that dissipation in the controller increases.

But because the motor is running slower, overall power is less than at full speed. If it does get too hot, there is an over-temperature thermostat to switch the controller off.

We cannot connect the high-voltage Mosfet directly in series with the 230VAC mains supply to the fan because Mosfets can only work from DC or at worst, from fluctuating DC. Any reverse current would be shunted by the Mosfet's intrinsic internal diode – so that wouldn't work.

The solution is quite simple though; we use a bridge rectifier. That way, the Mosfet is only subjected to rectified AC (or fluctuating DC) yet it can comfortably control the AC load of the fan.

Fig.1 shows the general arrangement. The Mosfet and current-sensing resistor connect between the plus and minus terminals of the bridge rectifier. When the active voltage is more positive than the neutral, current (i1) flows through the motor, diode D1 and through the Mosfet from plus to minus of the bridge, then through D3 and to neutral.

When the active is more negative than the neutral, current (i2) flows from the neutral through D4 and the Mosfet from plus to minus of the bridge and then through D2 and the motor to the active. The current flow through the resistive element is therefore always from the plus to the minus terminals of the bridge rectifier.

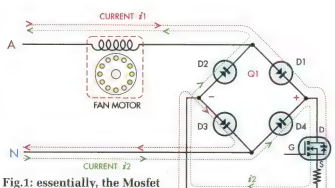


Fig.1: essentially, the Mosfet is a resistor in series with the fan motor but will only operate on DC, hence the need to run it via a bridge rectifier. Current i1 and i2 are the two halves of the AC waveform, so the motor is still fed with AC.

Circuit description

The circuit for the Fan Speed Controller is shown in Fig.2. It comprises just one IC, several diodes, the high voltage Mosfet, Q1, plus some resistors and capacitors.

The circuit and wiring diagram are for free-standing fans (ie, those connected via a 3-pin plug). For ceiling fans, some components are not required - we'll look at these later.

Power for the circuit is derived directly from the 230VAC mains. The entire circuit floats at mains potential so is unsafe to touch whenever the circuit is connected to the mains. Additionally, the circuit ground is also floating at mains potential and is not connected to mains earth. The metal box housing the controller is connected to the mains earth.

Mains power is supplied to the controller circuit via an IEC socket and fuse, F1, which is a part of the IEC input connector. Fusing protects the circuit against excessive current flow should a fault occur, such as a short across the motor.

BR1 is a 6A bridge rectifier with a 400V rating. As mentioned, the bridge provides the Mosfet with the positive full-wave rectified mains voltage while the fan motor receives AC.

A separate supply is provided for the low voltage circuitry. We use another bridge rectifier (BR2) and derive a low voltage supply via 220nF capacitors from the 230V mains. The capacitors are in preference to high wattage resistors since they do not dissipate significant power, therefore reducing heat dissipation inside the controller case.

The circuit shows the arrangement with the separate

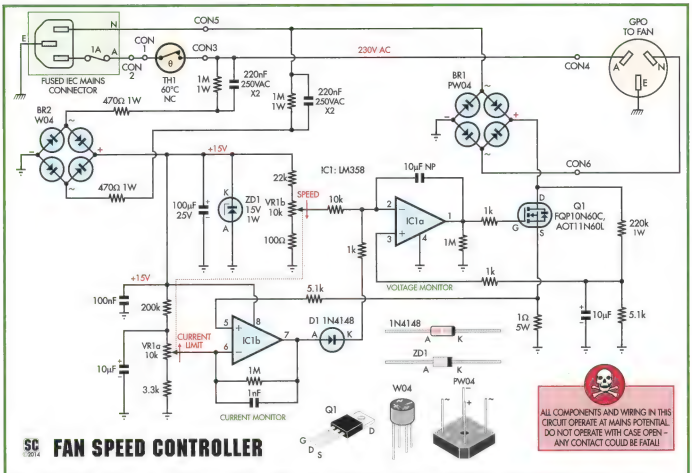


Fig.2: the circuit for our new Fan Speed Controller shows it has two bridge rectifiers, one of which provides low voltage DC direct from the mains. This is used to power the rest of the circuitry. The second bridge (BR1) allows a power Mosfet to control the current to the AC motor over both halves of the 230V mains cycle. The Mosfet acts like a variable resistor, supplying more or less power to the fan motor depending on the setting of VR1a&b.

rectifier (BR2) fed via two 220nF capacitors and series 470Ω resistors.

The 220nF capacitors provide an impedance that limits current flow to the 15V zener diode ZD1. At 50Hz, the impedance of each 220nF capacitor is 14.5kΩ. This impedance plus the 470Ω limits current to the 15V zener diode, ZD1 to about 10mA. A 100µF capacitor across the resulting 15V supply smooths it to a constant DC voltage.

The 470Ω resistors in series with the 220nF capacitors are there to limit surge current when power is first applied to the circuit. The surge current could be high should power be switched on at the peak voltage of the mains waveform. 1MΩ resistors across the capacitors are to discharge them when the power is switched off.

The 15V supply powers the LM358 dual op amp, IC1. One of these operational amplifiers, IC1a, is used to drive the gate of Mosfet Q1. This op amp is connected in a feedback control loop that monitors both a divided version of the voltage between Q1's drain and source and the voltage provided by speed potentiometer VR1b. IC1a adjusts its output voltage at the Mosfet gate so that the divided drain-source voltage across the Mosfet matches that set by the speed potentiometer.

In more detail, a 220kΩ 1W resistor and a 5.1kΩ resistor form a voltage divider across Q1 (ignoring the series 1Ω resistor). This effectively reduces the voltage across Q1 to about 1/44 its original value, calculated as (5.1k + 220k) ÷ 5.1k. The resulting voltage is filtered with a 10µF capacitor providing a DC voltage from the full wave rectified waveform.

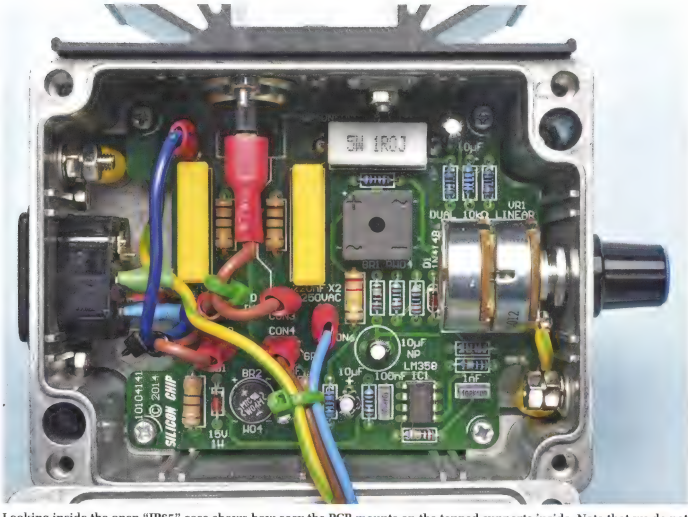
The resistive divider is there to produce a suitable low voltage for monitoring by IC1a. The maximum voltage needs to be several volts below the positive supply for IC1 at 15V. That's because the op amp is designed to operate with inputs that can go down to the negative supply but not as high as the positive supply.

Maximum voltage from the divider occurs when Q1 is at a high resistance. Then the full 230VAC of the mains supply is across the Mosfet. The peak of the 230V RMS waveform is 325V and after reduction by a factor of 44, brings the voltage down to 7.39V peak. This becomes 4.7V DC after filtering with the 10µF capacitor. Note that this average voltage of the full wave rectified waveform is 0.63 of the waveform peak.

As the resistance of Q1 is decreased, there is more voltage across the fan motor and less across the Mosfet. The voltage from the divider is therefore also lower.

VR1b is the speed control adjustment. VR1b is connected in series between a 22kΩ resistor from the +15V supply and a 100Ω resistor connecting to the 0V supply. With this resistor string, the voltage range for the wiper of VR1b is between 5V and 0.05V.

Operation is as follows: If VR1b is set to produce, say, 2V DC at its wiper, IC1a adjusts its drive to the gate of Q1 so



Looking inside the open "IP65" case shows how easy the PCB mounts on the tapped supports inside. Note that we do not have the IEC power lead plugged in – neither should you whenever the case is open!

that voltage monitored at the divide-by-44 resistors is also 2V DC. With 2V on the divider it means that there is 88V (average) across Q1.

The 88V average is equivalent to 97.5V RMS. If the mains voltage is at 230VAC RMS then the voltage across the fan is 230V - 97.5V or 132.5V RMS.

Note that for VR1b, the lower voltage is deliberately made to be slightly above 0V using the 100Ω resistor. This is to prevent IC1a from oscillation at the lowest voltage position for VR1b.

The voltage feedback control ensures that voltage across the Mosfet is strictly maintained to prevent changes in the motor speed. That's provided the mains voltage remains reasonably constant (which it usually does). Without the feedback control and just applying a fixed voltage to the gate of Q1, the fan would slow quite markedly as the Mosfet heats up. That's because the Mosfet drain to source resistance increases with temperature.

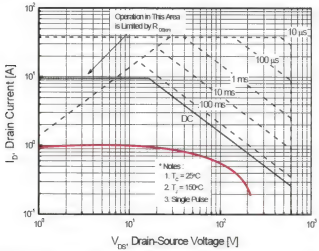


Fig. 3: SOA graph for the FQP10N60C Mosfet used in this project. The text explains how to interpret this.

Current limit

Current limiting for this circuit is necessary due to the fact that while the Mosfet can happily conduct around 10A, this is only when there is a relatively low voltage between its drain and source. With a high voltage between drain and source, the current needs to be reduced to prevent internal damage to the Mosfet.

Incidentally, no domestic fan (plug-in or ceiling) will demand anything like 10A. They're much more likely to be a tiny fraction of this – most fans are rated at 10-50W, which equates to just 40-220mA!

Fig.4 shows the Safe Operating Area (SOA) of the FQP-10N60C Mosfet. The lower DC, SOA line shows that the device can easily supply up to 10A to the fan motor but as

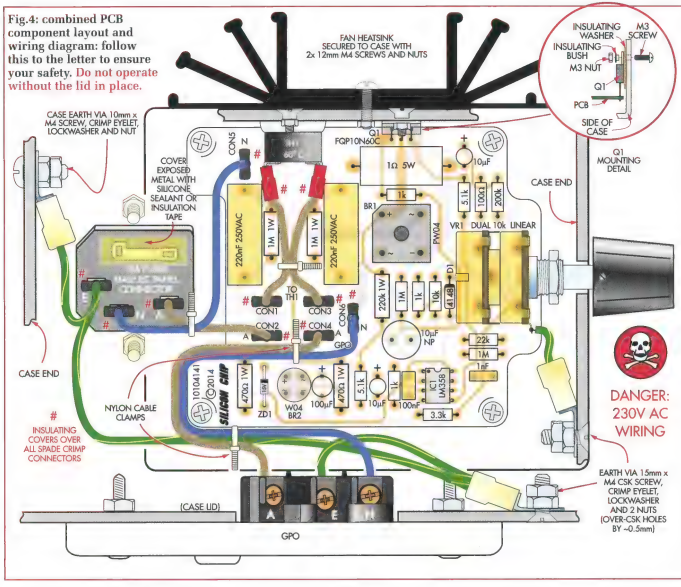


Fig.4: combined PCB component layout and wiring diagram: follow this to the letter to ensure your safety. Do not operate without the lid in place.

the drain-to-source voltage increases above around 20V, the Mosfet current rating falls, to 800mA at 200V.

The red line indicates the current limit our circuit applies to safeguard the Mosfet from exceeding the SOA. We restrict the maximum current to around 1A up to around 20V between drain and source. At this drain-to-source voltage, the fan will run at a fast speed. At lower fan speed settings, the voltage between the drain and source will be higher and we limit the current to prevent this exceeding the SOA curve. For the slowest speeds the current is limited to around 230mA.

Note that this SOA curve is for the non-insulated Mosfet package. For fully insulated Mosfet packages (eg. FQPF10N60C) both the SOA curve and thermal resistance from junction to case is worse. The thermal resistance is some three times higher. It means the insulated package, while more convenient for mounting, is unsuited for this application. The Mosfet would overheat internally regardless of the amount of heatsinking.

Additionally for the insulated package, for SOA, the 10A current rating is only for up to 5.5V drain to source. For these reasons we use the non-insulated Mosfet package.

IC1b provides the current limit function. It monitors the voltage across the 1Ω 5W resistor that is in series with Q1. The 1Ω resistor converts the fan current to a voltage. A 1A current for example will result in 1V across this resistor. IC1b is connected as an amplifier that has level shifting set by VR1a. As the voltage across the 1Ω resistor exceeds the voltage set at the wiper of VR1a, the IC1b output goes high and drives the input pin 2 of IC1b high via diode D1 and the 1kΩ series resistor.

This over-rides the motor speed setting, slowing fan speed to reduce current. If the current monitor voltage from the 1Ω resistor is less than the voltage set at the wiper of VR1a, IC1b output is low and thus has no effect on IC1a as diode D1 is reverse biased.

VR1a is connected across the 15V supply in a similar way to VR1b only the upper and lower resistors are different values. The 200kΩ and 3.3kΩ resistors set the VR1a current limit range to between 940mV and 235mV. Both VR1a and VR1b are physically connected to the one potentiometer shaft so adjusting fan speed will also automatically adjust the current limit.

Construction

With the exception of the mains input and output

sockets and thermal cutout, all components mount on a single PCB coded 10104141, measuring 93 x 79mm. It is designed to be housed in an IP65 diecast box measuring 115 x 90 x 55mm.

The PCB is shaped to match the internal contours of the IP65 case and has a cutout to fit the IEC input connector.

However, this case is relatively expensive – if you wish, the Fan Speed Controller can be built into a (slightly larger) economy diecast case instead. The PCB will then need to be mounted onto separate standoffs with four holes drilled in the base for these.

Begin construction by checking the PCB. We do not expect that there would be any problems with PCBs as supplied by the SILICON CHIP OnlineShop or with those supplied in kits. These are of high quality and are solder masked, screen printed and shaped with the required cut outs.

It is still worthwhile to check if there are problems with the PCB and look for any shorts or breaks between tracks. If there are any problems, repair these as necessary. Similarly, if the cut outs in the sides of the PCB have not been shaped, they should be cut and filed to size before any components are assembled.

Check that the PCB fits into the case before starting assembly. With the IP65 case specified, the PCB conveniently mounts on the integral tapped lands provided.

Follow the overlay diagram shown in Fig.4. Begin by soldering in the resistors, using the accompanying table for the colour codes. Diode D1 can be inserted next taking care to orient it correctly.

IC1 can be directly mounted or you can use an IC socket. Either way, be sure to install the socket and/or the IC the correct way around with the notch facing the direction shown on the overlay.

Capacitors can be installed next. The accompanying capacitor table shows the various codes that are used to indicate the capacitance values of the MKT polyester and X2 class capacitors. The electrolytic capacitors have their value directly marked and the polarised types must be oriented correctly.

The NP capacitor can be mounted either way.

You can use 10µF ceramic surface mount capacitors instead of the electrolytic types if you wish and provision has been made for these on of the PCB. If using these, position and tack-solder

Parts List – Deluxe Fan Speed Controller

1 PCB coded 10104141, 93 x 79mm
1 IP65 diecast box measuring 115 x 90 x 55mm (Jaycar HB5042 or equivalent)*
1 lid and side panel label
1 fan type heatsink 105 x 25.5 x 55mm (Altronics H0520, Jaycar HH-8570)
1 Architrave GPO outlet (Clipsal CLI16WE or equivalent)*
1 Male IEC mains connector with integral M205 fuseholder
1 1A M205 fuse
1 7.5A IEC mains lead
1 10A thermostat 60°C Normally Closed (Altronics S 5600, Jaycar ST-3821)
1 10k dual ganged 24mm PCB mount linear pot (VR1)
1 plastic knob to suit potentiometer shaft
6 6.35mm PCB mount male spade connectors, 5.08mm pin spacing (Altronics H 2094) (CON 1-6)
8 6.35mm insulated female spade quick connectors for 1mm wire diameter (red)
3 5.3mm ID insulated quick connect crimp eyelets for 2-5mm wire diameter (yellow)
2 M4 x 15mm countersunk screws (lid and potentiometer side earth)
3 M4 x 15mm screws (GPO and IEC end earth)
2 M4 x 10mm screws (securing heatsink when the case is M4 tapped) (use 2 M4 x 15mm screws and two extra M4 nuts when case is not M4 tapped)
8 M4 nuts
5 4mm star washers
2 M3.5 x 6mm screws (for PCB mounting) [in addition to the two supplied with case]
3 M3 x 10mm countersunk screws (for Q1 and TH1)
2 M3 x 10mm countersunk screws (for IEC connector)
5 M3 nuts
1 TO-220 Mica insulating washer
1 TO-220 insulating bush
4 small stick on rubber feet
1 200mm length of green/yellow 7.5A mains wire
1 200mm length of brown 7.5A main wire
1 200mm length of blue 7.5A mains wire
1 70mm length of 5mm heatshrink tubing
4 100mm cable ties
Heatsink compound

Semiconductors
1 LM358 DIP dual op amp (IC1)
1 600V 9A or more N Channel Mosfet (FQP10N60C, AOT11N60L, BUK457-600B) (Q1)
1 15V 1W zener diode (ZD1)
1 400V 6A P04 diode bridge (BR1)
1 400V 1.2A W04 diode bridge (BR2)
1 1N4148 signal diode (D1)

Capacitors
1 100µF 105°C 16V PC electrolytic*
1 10µF 105°C 50V NP PC electrolytic*
2 10µF 105°C C 16V PC electrolytic*
2 220nF 250VAC X2 class
1 100nF 63V or 100V MKT Polyester
1 1nF 63V or 100V MKT polyester

Resistors

(0.25W, 1%)

2 1MΩ	1 200kΩ	1 22kΩ	1 10kΩ
2 5.1kΩ	1 3.3kΩ	3 1kΩ	1 100Ω

(1W, 5%)

2 1MΩ	1 220kΩ	2 470Ω
1 1Ω 5W		

Notes:
An economy diecast box 119 x 94 x 57mm (Jaycar HB5064 or equivalent) can be used instead of the IP65 case. Extra parts required include 4 6.3mm M3 tapped standoffs & 8 M3 x 5mm screws. The two M3.5 x 6mm screws are not required.
If using the economy box, the Architrave GPO can be replaced by a standard sized GPO (HPM CDXL787WEWE or equivalent) (this will not fit onto the IP65 diecast box)
All the 10µF (polarised and NP types) and the 100µF electrolytic capacitors can each be replaced by 10µF surface mount ceramic capacitors (10µF 50V 3216 (metric)/ 1206 (imperial)). These will provide a longer service life than electrolytic capacitors. Provision has been made to mount these where each electrolytic capacitor would normally be positioned. Ceramic capacitors are not polarised so can be oriented either way on the PCB.

each in place, making sure they are aligned correctly before soldering them fully in place.

The diode bridges, BR1 and BR2, can be installed taking care to orient these correctly and in the right locations.

Before installing VR1, its shaft may need to be cut to length to suit the knob. The potentiometer nut is wound fully onto its thread. This nut is adjusted later to make contact with the inside of the case.

Finally, install the PCB spade connectors at CON1-CON6.

Mounting the hardware

A marking-out guide and panel artwork are provided on the SILICON CHIP website (siliconchip.com.au). This provides the IEC connector and GPO cut outs for the end and front panels. Details are given for both the IP65 and economy box.

First of all, mark out the hole position for the IEC connector and earth screw in the end wall of the case. There is about a 4mm gap from the base of the case to the bottom of the IEC connector. The hole is made by drilling a series of small holes around the perimeter of the desired shape, knocking out the piece and filing to shape. The earth screw hole is 4mm in diameter.

At the opposite end of the box, holes are required for the potentiometer and for a further earth screw. We used a countersunk screw here for the earth screw so that the end panel label would cover over the screw. In fact, we slightly over-countersunk this hole to ensure the screwhead was flush with the case surface.

Insert the PCB into the case. Note that the leads for Q1 must be kinked outward a little so that the metal flange of the device is parallel to and in contact with the side of the case. Mark the mounting hole position for Q1.

TH1 also mounts on the side of the box adjacent to Q1, with its attachment bracket is positioned so that the holes are vertical – the top hole about 7mm down from the top edge of the box.

Another view of the opened-out case, including the back of the architrave GPO. Note the earthing of the case lid – we don't rely on the metal-to-metal contact. Also note that the circuit ground and the case earth are most definitely NOT connected together – the circuit ground in fact "floats" at the mains voltage.

Both the TH1 mounting screws and that for Q1 are 3mm countersunk. Countersunk screws allow the heatsink to mount flat to the surface on the side of the case without too much counter boring in the heatsink where these screws sit.

Note that you will find it easier to install TH1 if the M3 nuts are tack soldered to the thermostat mount-

Resistor Colour Codes

No.	Value	4-Band Code(1%)	5-Band Code (1%)
4	1MΩ	brown black green brown	brown black black yellow brown
1	220kΩ	red red yellow brown	red red black orange brown
1	200kΩ	red black yellow brown	red black black orange brown
1	22kΩ	red red orange brown	red red black red brown
1	10kΩ	brown black orange brown	brown black black red brown
2	5.1kΩ	green brown red brown	green brown black brown brown
1	3.3kΩ	orange orange red brown	orange orange black brown brown
3	1kΩ	brown black red brown	brown black black brown brown
2	470Ω	yellow violet brown brown	yellow violet black black brown
1	100Ω	brown black brown brown	brown black black black brown

Capacitor Codes

Value	µF value	IEC code	EIA code
100nF	0.1µF	100n	104
1nF	.001µF	1n0	102

The two 220nF, 250VAC "X2" class will have values printed on them.

The 10µF and 100µF electrolytics can be replaced by surface-mount ceramic types (soldered to copper side of PCB).

ing bracket. To do this, place the screws into the thermostat mounting bracket (when it is out of the case) and screw on the nuts. Solder the nuts in place by applying solder to the side of the nuts.

The aptly-named fan type heatsink is secured to the side of the case on the Q1 side, using two M4 screws that either tap into the side off the case or use nuts. The mounting holes are placed along the centre line of the heatsink. The lower hole should be positioned high enough so it does not foul the PCB, especially if using nuts. The heatsink is positioned with its lower edge at the same level as the bottom edge of the box.

The holes for Q1 and TH1 mounting must be countersunk; we actually over-countersunk them by about 0.5mm to ensure that the tops of the screws were actually lower than the surface of the case – this allowed the heatsink to make intimate contact with the case and therefore ensure maximum heat transfer (aided by a dollop of heatsink compound).

Holes are also required in the lid to secure the switched mains outlet and the earth terminal. We used a countersunk screw here for the earth screw so that the front panel label would cover over the screw.

All holes must be de-burred on the inside of the case with a countersinking tool or larger drill to round off the sharp edge of the hole. This is especially so for Q1, where the edges must be rounded to prevent punch-through of the insulating washer. Run your finger over all holes to ensure there are no sharp edges – and also make sure no swarf is hiding in any of the box corners!

Specifications

Rating: ..... 80W maximum. Fused at 1A, 230VAC.
Speed adjustment: ..... Zero to maximum
Current limiting: ..... 235mA at low speed up to 940mA at high speed
Temperature cut out: ... 60°C (with 40°C cut in after 60°C cut out)

Panels

Artwork for the lid and end panels can be downloaded from siliconchip.com.au. Print them onto overhead projector film, photo paper or plain paper. We recommend overhead projector film – if you print in reverse, when it is placed on the box the printing will be against the case and protected by the film. The printouts can be cut to shape and adhered to the case with glue or silicone sealant.

Note that the countersunk earth screws for the lid and end panel need to be placed in position and temporarily held with a nut before placing the panels on.

Insert the PCB into the case by angling it so that the potentiometer is inserted into its hole first, then positioning the board onto the integral mounting lands inside the case. Secure the PCB to the case with the two 'supplied with the case' screws plus the extra two M3.5 x 6mm screws.

Secure Q1 to the case with an M3 screw and nut with a mica insulating washer and insulating bush as shown in the inset on the wiring diagram. Apply a smear of heatsink compound on all mating surfaces before assembly. We use a mica washer in preference to a silicone washer since the mica has a higher thermal conductivity (lower °C per Watt value) and the mounting screw can be tightened up more. This keeps the Mosfet cooler.

After mounting Q1, it is essential to check that the metal tab of the device is isolated from the case by measuring the resistance between the two with a multimeter. The meter should show a very high resistance measurement between the case and any of Q1's leads. Check your meter also reads close to zero ohms with a case-to-mounting-screw measurement. This will test if the multimeter is working and connected correctly.

The heatsink is attached using the two M4 screws, with a smear of heatsink compound between the mating surfaces.

Wiring

The complete wiring diagram is shown in Fig.4.

All mains wiring must be done using 250VAC, 7.5A mains-rated wire. You will need 200mm lengths of this wire in appropriate colours – brown (Active), blue (Neutral) and green/yellow (Earth). The easiest way to get these (if you're not building from a kit) is to cut off a 200mm length from a spare piece of 230V mains flex, strip off the outer insulation and – voila!

The earthing details of the case are most important since D1 and the potentiometer are all at mains potential yet are attached to the case. If the insulating washer or the insulation of the potentiometer were to break down, the case would be live (ie, at 230VAC) if it was not properly earthed.

The potentiometer needs earthing since the screw thread does not reach

Traditional (switched) fan speed controllers: how they work

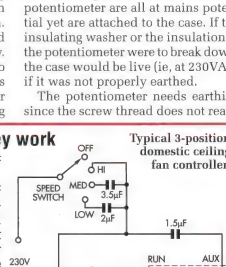
The circuit at right shows a typical switched-type fan speed control. The fan motor has two windings, with one winding powered at a different phase to the other to provide a rotating field. To achieve this, the "aux" winding is usually connected via a capacitor – in this case, 1.5µF.

For speed control, this also uses capacitors (or sometimes inductors) to reduce applied voltage to the motor "run" winding.

On the Hi setting, this winding receives full 230V AC power, so operates at maximum speed. When on the medium speed setting the run winding receives power via a 3.5µF capacitor in series and via a 2µF capacitor when switched to low speed.

At the 50Hz mains frequency, the 3.5µF capacitor has a reactance of 910Ω so the motor runs quite a bit slower than on full power. A 2µF capacitor has a reactance of about 1.6kΩ, so the motor runs that much slower again. Note that *lowering* the capacitance *increases* the reactance (at that frequency).

Most ceiling fans also have a summer/winter switch, usually mounted on the fan itself, which simply swaps the connections to the run winding. This reverses the motor rotation, to push air in the opposite direction.



far enough to the outside of the box for its nut to be screwed on to hold it to the case.

The potentiometer is earthed to the case by wrapping the earth wire around the location tab on the potentiometer and bending this down against the front of the pot. The earth wire is then soldered to this lug, ensuring there is sufficient heat for solder to flow onto the tab and wire – you may need to file or sand the lug first to remove any oxidation/passivation.

Be certain that the solder joint on the tap is not a dry joint.

The case lid is also independently earthed, as shown.

The IEC connector must be wired using the correct wire colours - brown for the active, blue for the neutral and green/yellow striped wire for earth. Use insulated quick connectors for the mains wiring connection to the PCB. Wires to the IEC connector need to be insulated with heatshrink tubing covering all exposed metal terminals for the active and neutral wiring.

Solder two earth wires onto the Earth pin on the IEC connector – one about 50mm long and other about 150mm. These wires should loop through the hole in the earth terminal with each wrapped back on itself so the wires are essentially captive before soldering to the terminal. Make sure the earth terminal is heated sufficiently with the soldering iron so the solder wets and adheres properly to both earth terminal and wire. Again be certain that it is not a dry solder joint. One end of the earth wire is crimped to the earth eyelet and the other to the earth eyelet on the lid and the GPO's earth terminal.

It is important to use one continuous earth wire length for the lid earth wire and GPO earth wire. Do this with just the insulation stripped back in the wire length to terminate into the crimp eyelet for the earth before running to the GPO's earth screw terminal.

The earth eyelets are secured with M4 screws, a star washer and nut. A second nut should be used as a locknut. As mentioned earlier, a countersunk screw is used for the earth on the lid and the potentiometer end panel - earth screws are placed before the labels are glued on. The IEC connector is secured with the M3 x 10mm countersunk screws, star washers and nuts. Similarly, the GPO is secured with M4 screws, star washers and nuts.

Finally, wires are secured using cable ties as shown.

Your speed controller is now complete – but don't forget to place the four rubber feet on the bottom of the case if you want to avoid scratching surfaces underneath.

Testing

Check all of your wiring very carefully against the overlay and wiring diagram. Also check that the case, lid and potentiometer are connected to the earth pin of the power socket - use a multimeter on a low ohms scale.

If you are satisfied that all is correct, you are ready to screw the lid onto the case.

Note that while the case is supplied with a rubber seal that goes around a channel in the lid to ensure its IP65 rating, we elected not to use this, so heat from the case can transfer to the lid for maximum dissipation.

Do not be tempted to operate the fan speed controller without the lid in place and screwed in position.

The easiest way to test the circuit operation is to connect a fan. First set VR1 fully anticlockwise, then plug a fan in, connect power and check that you can vary the speed with VR1. Note that the fan controller box will begin to run quite warm with extended use when driving the fan at lower than full speed. This temperature rise is normal.

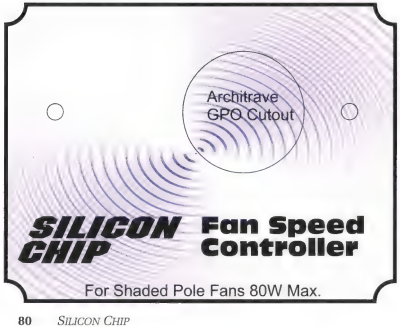
Troubleshooting the Fan Speed Controller

If the speed controller does not work when you apply power, it's time to do some troubleshooting.

First, a reminder: all of the circuitry is at 230VAC mains potential and can be lethal. This includes any exposed metal parts on components except those that are tied to the earthed chassis of the case.

Do not touch any part of the circuit when it is plugged into a mains outlet. Always remove the IEC plug from its mains connector before touching or working on any part of the circuit. Before going any further, give your PCB another thorough check. Check for incorrectly placed components and for component orientation. Again check solder joints.

Unless you have placed a component incorrectly or a solder joint is not properly made, there is very little that can go wrong with the circuit. It either works or it doesn't! So if it still doesn't work, check component placement and soldering once again.



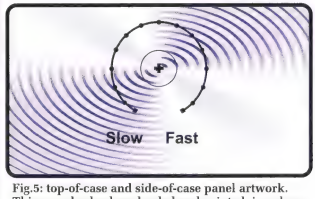


Fig.5: top-of-case and side-of-case panel artwork. This can also be downloaded and printed, in colour if you have the facilities, on thick paper or on overhead projector film, from siliconchip.com.au

Using with Ceiling Fans

While this project was originally designed as a controller for free-standing fans – ie, those that plug into a mains outlet – there is no reason why it cannot be used for permanently installed ceiling fans. Of course, this would mean that the box would have to be mounted on a wall with wiring into the ceiling fan connections installed by a licensed electrician.

Any existing "hard wired" switched-type controller could be left in situ – you'd simply leave it on its maximum setting and control the speed with this project.

There would obviously be no need for either the GPO on the case lid nor the IEC connector. Instead, wires would pass through cord-grip grommets or cable glands located in the side or base of the case.

You'd also need to fit an M205 safety fuseholder in place of the one integrated with the IEC connector.

Wiring

Wiring details for direct connection are shown below. The 230VAC mains wires pass through grommets and the neutral connects directly to the PCB as shown.

The active is connected to a separate panel-mounted safety M205 fuse holder (for the 1A fuse) that mounts on the case (or on the lid – ensure that it doesn't touch components underneath when the lid is screwed on).

We recommend using the SZ-2028 from Jaycar or the S5992 from Altronics. The active and neutral outputs from the fan controller then connect to the existing fan speed controller at its 230VAC input. The box must be earthed with earthing to the case, lid and pot body.

Note that the speed control box needs to be mounted so there is access to the control knob and so the box can keep cool (ie, you couldn't mount it in a small wall cavity). The diagram below doesn't show the heatsink but it must be fitted, in exactly the same way as detailed earlier.

While we haven't confirmed it, we don't believe you could use this project and an electronic controller together – if you couldn't remove the electronic controller, you could simply bypass it.

And as a light dimmer?

This circuit will also make a fine incandescent light dimmer and, as we mentioned earlier, won't put lots of impulse noise onto your mains wiring to swamp AM radio reception.

So for fancy incandescent bulbs, spotlights, etc (up to 60W) it will be fine to use as is.

And if you are talking about a standard lamp that plugs into the power outlet, the unit can be constructed as detailed earlier, without changes. Permanent installation would require the wiring diagram below to be followed.

However, like old-style (phase-controlled) light dimmers, it is not suitable for CFLs nor any other lights (LEDs, for example) which have electronic controllers (remember that most LEDs these days have them either inbuilt or as part of the fixture). SC

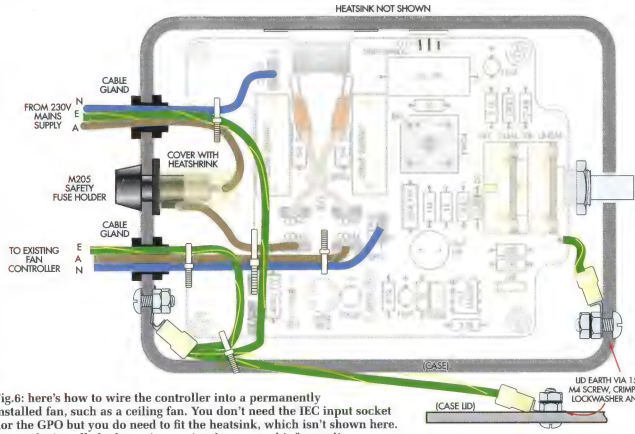


Fig.6: here's how to wire the controller into a permanently installed fan, such as a ceiling fan. You don't need the IEC input socket nor the GPO but you do need to fit the heatsink, which isn't shown here. It must be installed where air can circulate around it for cooling.

Salvage It!

By BRUCE PIERSON

What can you do with a dead UPS... or two?

If you've been following our recent series on ratting various equipment for parts, you'll realise that there is a lot more to it than meets the eye. Mostly you're just recycling components for the junk box... just in case! However, when it comes to Uninterruptible Power Supplies, they could be the start of a very worthwhile project. Especially if you happen to lay your hands on two of them!

Uninterruptible Power Supplies (more usually abbreviated to UPSs) are actually a misnomer. They certainly ARE interruptible – they are designed to give you enough time to save your work and then shut down the computer properly if there is a blackout (or even a momentary power interruption).

They do this by instantly switching over to a battery-powered inverter when there is any loss of mains power.

However, with rare (read $$$$!) exceptions, they are not designed to let you keep working indefinitely. That's because the internal battery will only deliver power for a relatively short time. And when that battery runs down, you're definitely powerless! Or up the creek without a paddle. And so on!

The reason most UPSs fail is that their batteries fail – and that's usually a relatively easy fix. Replace the battery (in most cases, they use SLAs) and the UPS should be good for another couple of years or so.

Because SLA battery failure *is* so common – and to help prevent it, SILICON CHIP published the "Battery Lifesaver" in the Septermber 2013 issue. If you use SLA or Lithium batteries, it's well worth a look – you could save a lot of money in batteries!

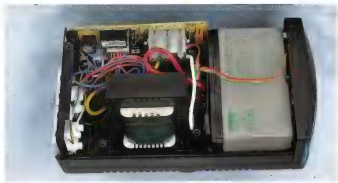
But there are other causes of failure, too – and like many things electronic, replacing an old, tired UPS with a modern one usually makes more economic sense than troubleshooting and fixing it.

Ergo, you might come across a "junked" UPS one day.

But before attacking it for parts, if you have a suitable (ie, same voltage, even if not the same capacity) SLA battery that you can easily hook up, you might find it's a goer. Lucky you: replace the battery with one of the same ratings and you won't have to worry about losing work again!

Strip it!

But if it doesn't kick into life, don't bin it: you could strip it for parts. Assuming that the transformer itself isn't the part that failed, at the very least you will have a quite



First step in diassembly is to get the covers off – and some manufacturers treat this as an intelligence test! Hidden screws, specific order of removal and so on can often be a real pain. But in the case of UPSs, they know that at some stage the SLA batteries will have to be replaced so they usually aren't as difficult as many other devices. Incidentally, before we started disconnecting everything we temporarily replaced the batteries to make sure these units were dead. They were!

"grunty" low voltage transformer, (usually about 12-20V at perhaps 10A) along with attendant rectifiers and so on. Of course, those bits are very handy in their own right – for instance, you can make quite a nice battery charger – or you can make up a great low voltage bench power supply.

If you're fortunate enough to come across two (identical) UPSs, you might think about making an isolation transformer (more on this one anon).

But let's first look at breaking down a UPS for parts.

The pictures above show two UPS units. The smaller, black one has a plastic case, whereas the larger white one has a steel case with a plastic front panel. The smaller one is a newer model which was fitted with a single 12V SLA battery while the larger, older one was fitted with two 12V SLA batteries.

Where to start? It goes without saying (so we'll say it anyway!) – unplug the UPS from the power before you do anything.

We'll start with the smaller unit with the plastic case. These cases are a bit of a hassle to take apart. First remove the front panel. This is usually held on by a clip or clips at the bottom of the case, so it's a matter of working out how the clip works, so that it can be disengaged and the front panel removed. After that, there will be a number of screws securing the two sides together, so once these are removed, the topmost panel can be lifted off to reveal the contents of the UPS.

For the larger unit with the steel case it is more straightforward to remove the cover. It will usually simply have screws holding the cover on and once these screws are removed, the cover can be slid backwards and/or tilted up from the back to remove it.

Now that the cover is off, it's just a matter of proceeding to undo screws and remove all the parts and we can see what we have from the exercise. The parts available will vary from one UPS to another, depending on their age and rating. Other UPSs may have somewhat different parts to these units, but something similar.

So, what did we get from these two UPSs? We'll start with the smaller unit. The picture below left shows the partly disassembled UPS.

From this unit, we salvaged the following parts:

- A plastic case that could be good for a project. However, it will be necessary to make a new rear panel for it, due to the sizes of the holes in the existing rear panel. This is straightforward, as it just requires a suitable piece of hard plastic or aluminium. The old panel can be used as a template, once the parts are removed.
- A transformer with output voltages of 7V – 0 – 7V at 10A or more plus 15V at 1A
- Two mains sockets (often UPSs will have IEC sockets, which are

The two UPSs partially broken down. The one at left is significantly simpler (and lower capacity) than the older model at right – the advantage of the older model is that yielded significantly more bits and pieces.

commonly used in projects)

- One IEC male mains socket with built-in fuse. Handy for use in a project instead of a standard mains cable.
- The dead battery went to the recyclers (never put dead batteries in the garbage bin).
- A PCB with the following components for later removal: 9 electrolytic capacitors, 5 3A diodes, 2 1A diodes, 4 relays, 1 IC, 1 5V regulator, 2 TO-220 transistors, 3 dual diodes, 1 small heatsink, 2 high voltage capacitors, 1 USB B PCB socket, 1 small PCB speaker and a range of SMD components on the back of the PCB.

WARNING!

This is a mains-operated device and all wiring must be run using 250V AC rated cable. Any exposed metal (eg, screws) must be earthed. If you use the metal cased version of the UPS, ensure that the case is earthed.

So that was a very worthwhile exercise. The power transformer in particular will be very handy. The original case could even be utilised for the case of the project. It's just a matter of adding the other components and you've turned a useless piece of junk into something useful.

Now we'll look at what we got from the larger, steel case unit:

- 1 steel case with a plastic front panel. This case is not in the best of condition but it can be resprayed easily. We left the mains switch and the two fuse holders in it. The other holes can have a small plate fitted to cover them. The mains cable was removed and an IEC socket will be fitted, instead of having a captive mains cable.
- 1 transformer with outputs of 16V – 0 – 16V at up to 10A plus 28V at 1A – 2A and 15V at 1A and 35V at 1A. A very useful transformer suitable for many projects.
- 2 PCBs with the following parts for later removal: 16 electrolytic capacitors, 17 ceramic capacitors, 7 greencap capacitors, 5 tantalum capacitors, 4 TO-3 power transistors, 1 LM317 voltage regulator, 3 TO-220 transistors, 4 5W resistors, 8 ICs, 4 trimpots, 14 small transistors, 4 PCB fuses, 1 relay, 2 X2 capacitors, 1 thermistor, 1 mains filter choke, 1 30W resistor, 1 large heatsink, 1 small heatsink, a range of SMD components on the top of the PCB, 2 mains sockets, 5 brass threaded PCB standoffs, 3 cable tie-points, 2 cable ties, 1 mains cable, 1 mains cable clamp, some hookup wire, 8 screws, 3 nuts, 2 spring washers, 2 insulation sheet from under PCBs.

Another very worthwhile exercise in salvaging very useful components from what was a "useless piece of junk".

The larger steel case will be very useful for a project and the power transformer is particularly versatile, with a large range of output voltage options. There's even four big power transistors already on a large heatsink that can be pressed into service.

Not all UPSs will have such large heatsinks and power transistors, as newer models tend to have smaller components than the ones in this particular UPS.

Any salvaged components must of course, be tested to make sure they are good. Never use an untested component in a project or a repair, because if the component is faulty, you will be introducing a fault that wasn't there to start with.

A typical transformer (not from the UPSs) showing the various windings – the primary, in this case, is the red-sleeved pair, with three secondaries – white, blue and yellow (with black centre-tap). Use a multimeter on a low Ohms range to identify the different windings.

Testing the transformer

When you have a transformer with unknown connections, especially from equipment that wasn't working, it is necessary to determine which wires are which. Most important is the primary – the mains input. If you wire it up incorrectly, you can permanently damage the transformer and blow a fuse or trip a circuit breaker. Often, a UPS transformer will have multiple wires that could be the mains input, or could be a low voltage output at a lower amperage, so it's important to differentiate between them.

Before you start, make sure you are using a power point that is protected by a safety switch (also known as an RCD, or residual current device). If you are in a building that does not have safety switches either at the switchboard or as part of the wiring, then buy a portable safety switch. These are not expensive and could save your life if you happen to contact a live wire.

Incidentally, if you are not sure if there is a safety switch or not, there's no harm in connecting a portable safety switch to a circuit which already has one.

So here's the best way to proceed. First, identify any very thick wires. These will be secondaries. If you only have one set of thick wires and one set of thinner wires, then that's pretty straightforward, as the thinner wires will be the primary. However, there may be multiple sets of thin wires, so some caution is required. First, test these wires with your multimeter and find out just how many sets of wires are connected to individual windings. Having identified the individual sets, choose the set with the highest resistances. Then in this set, identify the two wires with the highest resistance between them. These will more than likely be the ones to connect to the mains and in many cases will have the same colour insulation or may even be coloured brown and blue (or red and black in older transformers).

Next, use a mains-rated terminal block to connect the Active and Neutral wires from a 3-wire mains cable to these two wires, with the earth wire to the frame of the transformer. Again, for safety this should be done on a circuit fitted with a safety switch at the switchboard (ie, an earth leakage detector or RCD) or if there isn't one, use a mains lead fitted with a portable unit.

Plug the cable in and turn on the power. Assuming it's not humming or buzzing madly, getting hot or smoking,

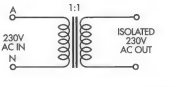


Fig.1: a "traditional" isolation transformer has two identical windings – feed a voltage in one winding (the "primary" and you'll get a very similar voltage on the other (the "secondary"). However, the two are not connected in any way. While this has theoretically identical voltages, you can expect minor losses. And you do need to ensure the power rating of the transformer is not exceeded.

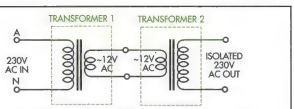


Fig.2: you can make an isolation transformer using two identical transformers connected "back to back" – this achieves exactly the same result as a single transformer with two windings. Once again, the power rating is important – you cannot draw more current from the transformer than it was originally intended to supply. Losses will be slightly higher because two transformers are used.

you can now carefully measure what voltage is on each of the secondaries and make a note this, either by writing on the transformer or by putting tags on the wires. Use your multimeter on a suitable "AC volts" range.

You may think that you can't use a UPS transformer as a mains transformer, because the operation of the UPS is to turn battery power into mains power. However, this is only when the power goes off. In standby mode, the transformer actually supplies low voltage to keep the battery topped up and to power the rest of the circuit. When the power goes off, a relay trips and changes the mode of operation to supply mains equivalent power from the battery, so it's perfectly safe to use a UPS transformer permanently as a step-down transformer. Just don't try to exceed the current capacity of the transformer. This rule applies to any transformer, regardless of its source.

Why not make an isolation transformer?

If you're lucky enough to come across two identical UPSs, you're going to end up with two identical power transformers. How about connecting them together to create an isolation transformer for general service work, troubleshooting and so on?

What is an Isolation Transformer? As its name suggests, it's a transformer that supplies a voltage isolated from another – in this case, 230VAC which is not connected to, or referenced to, either the mains or to earth. In simple terms, you feed in 230VAC from the mains and you get out 230V AC that isn't connected to the mains.

Why would you want to do this?

As you would know, the 230VAC mains normally has three wires, the Active, Neutral and Earth. Two of these, the Neutral and Earth, are (or should be) connected together at your switchboard so, theoretically at least, are at earth potential, or 0V (this assumes you have a good Earth connection, which isn't always the case).

The Active wire has a potential 230VAC relative to Earth. Having Neutral and Earth at 0V has both good and bad points. It's mainly a safety measure where a fault to earth will generally be enough to blow a fuse, rendering the device relatively safe.

However, the bad point is that if you touch the Active, the chances are very good that some part of your body will be at Earth potential and you will receive an electric shock which is at best life threatening.

Note that you don't have to physically touch both the Active and Neutral/earth lines at the same time. Just touching the active is often enough to kill you due to the path through your body and feet to earth – which can be a damp floor, metal frame of a building, and so on. The point is, electricity flows through your body and upsets the impulses controlling the muscles which make your heart beat.

With an isolation transformer, because it is not referenced to earth, you can accidentally touch either wire with relative safety, even if you're standing in a puddle of water! But touch both at once, if you form a path via your heart (eg, from hand to hand) you can get killed just as easily!

A couple of "for instances": if you are working on mains-powered equipment with a "live chassis", then an Isolation Transformer is a must for safety.

Another situation would be trouble-shooting an earthed appliance that has a slight earth leakage. If you don't have a safety switch, this appliance will happily function normally without any problems. However, if you have a safety switch, then you can expect the safety switch to be tripped either repeatedly or on a semi-regular basis. That's a good indication that you have a fault, by the way – something that must be corrected as a matter of urgency. An isolation transformer will help locate the fault without continual tripping of the safety switch.

Thirdly, an isolation transformer may be of assistance in tracking down various other mains-related faults.

How is an isolation transformer constructed?

In the vast majority of transformers, (of any description) the primary and secondary windings are isolated from each other – in fact, the isolation is often specified and it should be rated at several thousand volts. Primaries and secondaries are usually wound on two halves of a plastic bobbin, thus both physically and electrically isolated. Even transformers where the primary and secondaries are wound over each other – such as a toroidal transformer – have very good insulation between the two.

So it is with an isolation transformer, except that the primary and secondary windings are identical.

Feed 230VAC (from the mains) into one winding and you'll get (by transformer action) an isolated 230VAC from the other winding (ignoring losses).

Incidentally, auto-transformers are the exception: here the secondary *is* connected to the primary. So they can be dangerous beasts to be treated with due diligence!

How are we going to replicate this arrangement?

Remember that with any transformer, the voltage out is simply a function of the voltage in and the "turns ratio". If you have a transformer which is normally 230V AC in

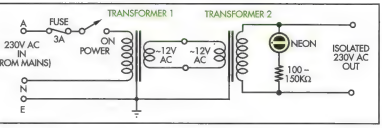


Fig.3: here's the final cicuit of our isolation transformer – very similar to Fig.2 but with the addition of a fuseholder (part of the IEC mains input connector), a power switch, an earth connection to both transformers plus a neon indicator to show that power is available. Maximum power of this setup is 920W (or 4A).

and 12V AC out but feed 12V AC into the secondary, you will get 230V out from the primary.

Which is exactly what we are doing here: we will use two identical UPS transformers and connect the low voltage windings together to achieve this result. Fig.1 shows a conventional Isolation Transformer while Fig.2 shows our version of an Isolation Transformer.

As long as we keep within the power rating of the transformers, we get what we want – isolation between input and output.

Making it

First, we need two identical transformers from old UPSs. These must be identical in order for the above arrangement to work correctly and produce the same voltage at the output as the input. Next, we need a power switch, a fuse, a neon indicator with, say, a 150kΩ resistor and a case.

Usually, one of the UPS boxes that gave you one of the transformers can be pressed into service. It will already have the mounting positions for one transformer, so it should be relatively easy to mount the second transformer. The components are wired up as in Fig.3.

Assembling the unit

Now that you have a suitable case and you have been able to mount both transformers in the case, it's time to wire it all up. Follow the wiring diagram to make sure that everything works as expected. We used two 7V – 0 – 7V transformers. The centre-tap was not used, so these wires were coiled up out of the way – make sure that any bared ends of wire are suitably insulated.

Due to the thickness of the wires on the secondaries, it was decided that the most practical way to connect them together was to use a heavy-duty terminal block as shown in the photo below.

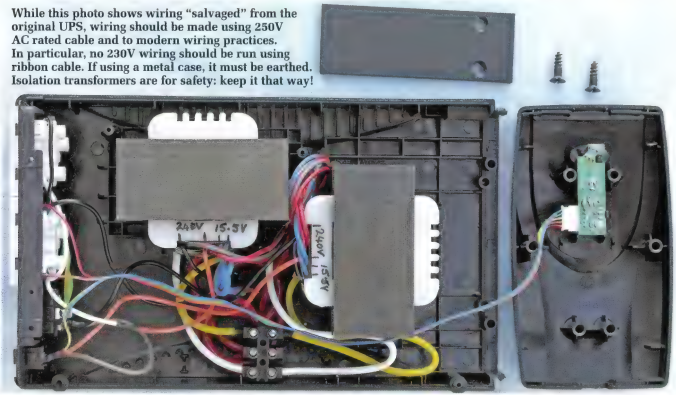
The primary wires on the input transformer were soldered to the terminals on the power switch and IEC socket while the wires on the output transformer were joined to the wires from the GPO sockets on the back panel and soldered and heat-shrinked.

This particular case already had two GPO sockets and a fused IEC socket on the back of the case as well as two other holes. One hole was filed out to suit the power switch and the other hole had a piece of black plastic super-glued on the inside to fill it in.

The picture below shows the arrangement with the UPS case and transformers that we used. The small black cover at the top of the photo was made to cover the front panel PCB for safety, as it has pads at 230V potential.

The original case required some minor modifications to house the second transformer which was housed where the battery was originally located. As the transformer was thicker than the battery, the case had some of the ribs trimmed back by initially clipping them out with side-cutters and

While this photo shows wiring "salvaged" from the original UPS, wiring should be made using 250V AC rated cable and to modern wiring practices. In particular, no 230V wiring should be run using ribbon cable. If using a metal case, it must be earthed. Isolation transformers are for safety: keep it that way!



then finally trimming them level with a wood chisel. Be sure to wear safety glasses while performing this operation, or you might find yourself wearing a sliver of plastic in your eye instead. Very unpleasant!

If using a steel case, it will most likely be easier to mount the second transformer on the base of the case, adjacent to the original transformer.

The case we used originally had three LEDs on the front panel. We removed the three LEDs and replaced the bottom LED with a neon indicator and fitted an appropriate resistor, in this case 150kΩ 1W (1W needed for its higher voltage rating), as this miniature neon did not have an integrated resistor.

The photo at right shows the front and rear of our Isolation Transformer. It has two power outlets, fused IEC connector and power switch. It might appear that the fuseholder/fuse is on the "wrong side" of the power switch – surely it should be after the switch so that the mains is not connected when the switch is off?

In theory, that is absolutely correct; however, the fuseholder is integrated within the IEC mains input connector so must be connected this way around. The fuseholder cannot be accessed unless the IEC mains plug is first removed.

The remaining hole on the left-hand side of the back panel near the bottom was filled in by gluing a piece of black plastic to the inside of the back panel with super-glue but epoxy glue would be a better choice.

So there you have it. An Isolation Transformer for very little cost. Just wreck two identical dead UPSs and use the two transformers and a few other bits and pieces and one of the cases.

Front and rear of our UPS-based Isolation Transformer. We've used most of the rear-panel components of the UPS "as is" and mounted the second transformer inside the case. The bright red Neon shows that the unit is powered up.

In our case, we have a 920VA unit, as that was the original rating of the UPS before it was wrecked for parts. That's a saving of around $400.

Not bad for an afternoon's work in assembling the unit, as we had the required parts on hand from previous recycling exercises. SC

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Or that even with its exceptional bass response, *it has a treble that really sings?*

Have we whet your appetite? Good. Because you'll find the construction details in the June issue of SILICON CHIP.

On-sale date: Thursday, 29th May.

Tektronix MDO3054 "Six-in-One" Mixed Domain Oscilloscope

Just what you've always wanted... a four-channel digital storage oscilloscope, logic analyser, protocol analyser, spectrum analyser and arbitrary waveform generator with digital voltmeter and frequency counter in a single package!

You may recall our review of the Tektronix MDO4104-3 Mixed Domain Oscilloscope in the November 2011 issue.

It was (and still is) a very clever device, capable of 'freezing time' like a DSO but operating in both the time and frequency domains, ie, alongside the waveforms from the four analog and sixteen digital channels it could also display a time-correlated RF spectral analysis.

We were very impressed with this capability but the price of the MDO4000-series scopes puts them out of reach for many.

The just-released MDO3000-series also combines a scope and spectrum analyser (plus some other functions) in a more affordable package.

This unit is part of the recent trend to try to integrate as many extra functions into a scope as possible. We've seen mixed signal scopes with waveform generators and DVMs before but by adding the spectrum analyser in as well, the MDO3000 is the current "king of the mountain".

Common features

The overall instrument is fairly compact given its screen size and the number of knobs and buttons – it measures 417 x 204 x 148mm (not including carrying handle) and weighs 4.2kg. It's somewhat wider than the most compact scopes but that's due to the large 23cm (9") display which has excellent colour and contrast and a reasonably good viewing angle too.

While the big handle makes it taller, it certainly makes it very easy to carry, too. Overall, it does not seem unwieldy.

There are soft buttons on both the bottom and right edges of the screen, which simplifies the operation of the menu system somewhat, along with the two general purpose knobs (rather than one as is typical). As you can see from the photograph, there are plenty of specific-function knobs and buttons too.

While it does take up more physical space, we prefer having separate vertical controls for each channel as it makes operation simpler. Overall, the control layout on this scope is above average and we quickly got used to the location of most buttons as they are positioned logically.

When both multi-purpose knobs ("a" and "b") are active, on-screen icons show which one does what and you quickly get used to looking for those icons. The zoom/pan knob is pretty easy to operate too, with the pan function being spring-loaded and the zoom 'jog wheel' within it.

The spring-loaded pan wheel gives a scroll speed is proportional to how much force you're applying and allows for quick panning.

You will notice that there are some extra buttons on the right side compared to a regular scope and these are the numeric keypad and mode buttons for the spectrum analyser, which means its controls are mostly separate to the rest of the unit.

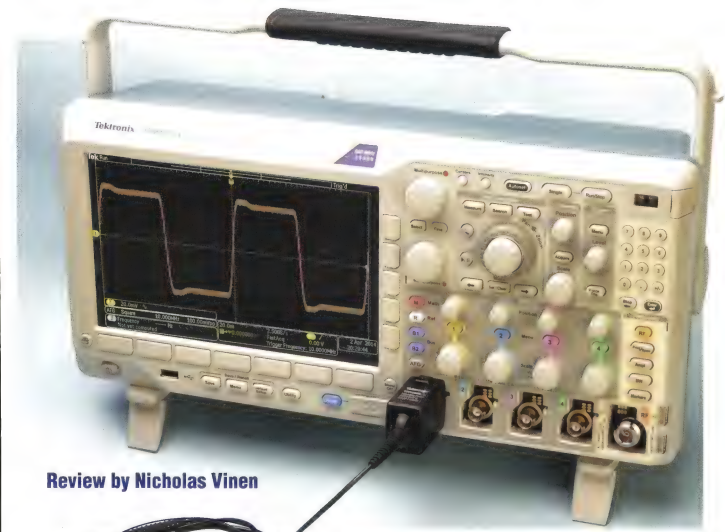
The spectrum analyser shares some knobs and the soft buttons with the scope but we think they could have used more of them; for example, the pan and zoom controls do nothing in RF mode whereas they could have been used to adjust the span.

While the numeric keypad is primarily used for the spectrum analyser, you can use it for entering numbers in other situations such as when setting the signal frequency and amplitude for the arbitrary waveform generator.

This is certainly quicker and more accurate than twiddling knobs. You can also plug in a USB keyboard instead to make it even easier (and that also simplifies typing labels and file names).

Capabilities

The spectrum analyser section operates similarly to stand-alone spectrum analysers that we have used and its performance is good, on par with a decent stand-alone unit. Essentially, it's a separate instrument that shares the



Review by Nicholas Vinen

The large screen and generous number of 'soft buttons', plus the well-organised control layout make driving this unit quite straightforward.

display, controls and power supply with the rest of the device. It does take up a lot less space than having two separate devices and there is also the advantage of only having to learn one control interface.

The spectrum analyser input is an N-connector. If you're at all serious about using the spectrum analyser you will need to pay for the 3GHz bandwidth option; otherwise, it is limited to the same bandwidth as the scope inputs, ie, 100MHz-1GHz.

But even 1GHz may not be enough as many users these days will be looking at WiFi, Bluetooth, Zigbee etc, all above 2GHz.

By the way, all software-controlled options are enabled for the first 30 days of operation. That includes the 3GHz spectrum analyser bandwidth. It also includes the logic analyser serial bus decoders. After that time, you will need to pay for the options if you want to continue using them.

The spectrum analyser is FFT-based and has all the features you would expect such as a very wide capture bandwidth of 3GHz which means you can look at the whole spectrum in a single display (see Fig.1).

We've set the resolution bandwidth to be much finer than the default for this span (at 30kHz rather than 3MHz) as this lowers the noise floor and improves peak discrimination at the expense of display update rate.

Fig.1 also demonstrates the automatic markers and averaging features. The unit can also make some basic measurements on the RF signal: channel power, adjacent channel power ratio and occupied bandwidth.

Note though that unlike its bigger MDO4000-series cousin, the scope and spectrum analyser functions are essentially separate and can only be used one at a time. So if you want to be able to see the scope inputs and spectrum analysis on the same screen or be able to freeze the instrument and then do spectral analyses at different points in time, you will have to spring for the higher end unit.

Accessories

As you would expect, the scope is supplied with two or four passive probes that have equal or greater bandwidth than the scope itself. The probes supplied with our demo unit were 500MHz 10:1 types, although they didn't actually indicate the division ratio on the probes anywhere we could see (which is somewhat unusual).

These are high-quality probes and the hand-held portion is quite small; we like that, standard probes seem pretty bulky in comparison with modern circuitry and can really get in the way when you are trying to measure several parameters at once on a small, tightly-packed PCB. The cables are

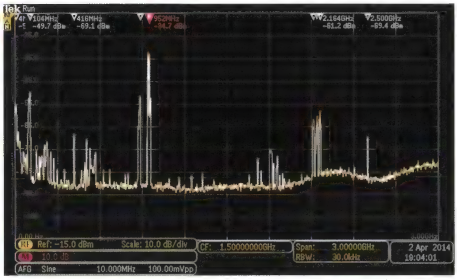


Fig.1: we connected a 2m length of wire to the RF input and ran a spectral analysis over the full span of 10kHz to 3GHz. Automatic cursors are enabled, giving peak details at the top of the screen. The low resolution bandwidth gives a relatively low noise floor but does slow down screen updates with such a large span.

very flexible which also helps when probing cramped PCBs.

Interestingly, while the probe inputs are BNC sockets, the probes are actually held in place by a spring-loaded clip integrated into the boxy section. This has a button which you hold down to release the probe and it can then be pulled free.

Once you get used to it, this makes connecting and disconnecting probes quite convenient.

If you purchase a mixed-signal scope (ie, a model with the logic analyser enabled) then logic probes are also supplied. The analyser has 16 channels which is good; some scopes only have eight and while that is plenty in most circumstances, if you need to monitor two SPI buses plus a few digital I/Os, it won't be enough.

All versions are supplied with an IEC mains cord and accessory pouch which can be used to hold the probes and so on. They also come with a small manual and a CD with the rest of the documentation. The quality of the documentation is above-average and it includes clear explanations of what the various options and modes do.

Other functions

As DSOs go this one actually has a lot of features, both in terms of hardware and software. Hardware-wise, it comes standard with 10Mpoints memory per channel which is great. It supports active probes and can auto-detect compatible probes when they are connected. It also has Ethernet and VGA interfaces by default.

What about HDMI, you might ask? VGA is rapidly becoming obsolete. This seems to be an industry-wide issue; presumably scopes with HDMI outputs will appear soon but for the moment, if you want to connect an external monitor or projector to a scope, you're stuck with VGA.

The DVM feature is free after completing a registration form. This gives more accurate voltage measurement for low-frequency signals; the reading has four digits rather than the three you get in measurement mode but for AC (RMS) measurements, it is only good for signals up to about 10kHz. It also incorporates a 100/150MHz frequency counter (depending on scope bandwidth).

While this is handy to have, it doesn't have the same precision as a good multimeter and lacks the other features such as current measurement, capacitance, resistance etc. One day those functions will probably be integrated too but for now you'll still need a multimeter or two.

The arbitrary function generator option is quite handy and can produce a variety of signals up to 50MHz. It operates at 250 megasamples per second and can generate arbitrary waveforms with up to 128k points. The output is at the back which is a little inconvenient but you can leave a BNC cable attached semi-permanently. There is only one channel.

For mixed-signal models, the logic analyser input is conveniently located at the front, near the other probe connections and has a relatively small ribbon that splits out into two logic heads. It's supplied with the usual IC clips.

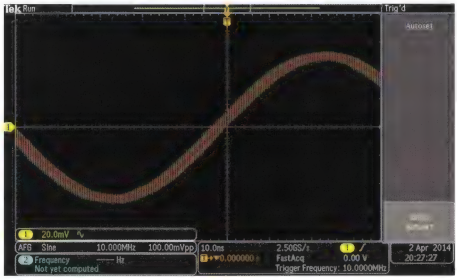


Fig.2: the 'temperature' display in FastAcq mode which is used to enable maximum waveform update rate. This is used to detect runt pulses, check outliers, determine jitter and so on. The colour indicates 'hit density' with the hotter (more red) colours indicating more commonly sampled values for that point in the waveform.

Software features

We won't describe all the usual DSO features which of course are present, such as cursors, waveform measurements, statistics, averaging mode, high-resolution acquisition, zoom and pan, waveform mathematics ("math"), reference waveforms and so on. It has all the modes you'd expect and more. "Math" mode includes an FFT function – we guess this is still useful since the spectrum analyser has a separate input.

One interesting feature of this scope is that it can display statistical histograms of time or voltage data. For example, it can plot a graph showing the distribution of jitter in a pulse train.

You can also take measurements from the histogram such as mean, standard deviation, 1st, 2nd, 3rd, Sigma values (percent of values within 1, 2 or 3 standard deviations) and so on.

Like the MDO4000-series, the MDO3000-series has a particularly powerful 'math' mode where you can not only do basic calculations such as adding or multiplying two traces, you can actually enter a mathematical formula based on the time domain values of one or more traces to produce a new trace which is then displayed on the screen.

This can include functions such as integration and differentiation and is a very powerful feature – but you will probably need to plug in a USB keyboard so that entering formulas is not too time consuming.

The "Wave Inspector" zoom/pan control group also includes buttons to search for and mark events in the recorded waveform, using similar logic to that which is used for triggering the scope; in fact there is an option to use the trigger settings to mark events. You can then skip between these markers and you can place manual markers which can be handy if you are moving around a lot in a long record and want to remember your place.

The triggering system is quite powerful and includes sequential triggers (ie, edge on one channel then another), triggering after multiple edges, depending on pulse-width, on runt pulses, a logic combination, on setup/hold timing violation, depending on rise/fall time, on video frames (including HD) and on logic bus packet contents, assuming you have that bus decoder option installed.

There are a couple of very nice aspects to the measurement system on this scope.

One, for measurements which involve analysing data over a time period such as RMS, you can select that time period, eg, over a single cycle, over all the cycles displayed on the screen or all the cycles recorded in memory. You can also have it use the area between the cursors to do the calculation.

You also have the option to turn on 'indicators' for a given measurement and if selected, this displays a set of automatic cursors which show how the measurement has been calculated. For example, if enabled with a frequency measurement, two dotted cursors appear which show the two points in the waveform used to determine the signal period.

Fig.3: here we have turned on a lot of different features, with the digital voltmeter/ frequency counter at top, zoom window below, then the graticule, status display, two measurements plus the menus. Obviously you would not normally turn these features all on at once as it leaves little room for the traces!

We especially like the fact that you can select which measurement to display the indicators for and that you can turn it off if you don't need it, to de-clutter the display.

While all the features mentioned above come standard, there are some that come at extra cost (but as explained above, with a free 30-day trial). This includes limit and mask testing (MDO3LMT option) and power analysis (MDO3PWR option) including power quality, switching loss and harmonics.

The logic analyser is also an optional extra and on top of that, there are various serial bus decoder modules you can purchase, including audio, CAN/LIN, RS-232/422/485 and I²C/SPI.

There is also an option for USB 2.0 triggering and analysis for low-speed and full-speed devices (ie, up to 12Mbit). With this option and a scope with 1GHz bandwidth, you can also

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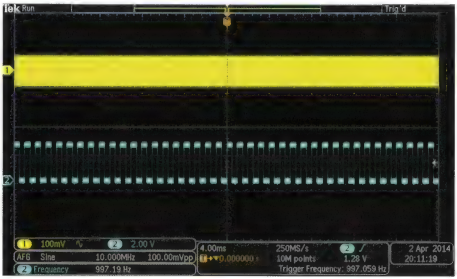


Fig.4: luckily it only take a few button presses to de-clutter the display; this shows the maximum amount of screen space available for the graticule, with just the static display at bottom (which can be turned off but just leaves an empty space). The large screen space comes in handy for viewing multiple waveforms in details.

Vintage Radio

By John Carr

The AWA B30: a transistor radio just like grandma's

The AWA B30 transistor radio is built into a leather case and has just two controls: a large handspan dial and roller volume/power switch at top left.

I VIVIDLY RECALL my grandmother listening to her little AWA transistor radio. It was an AWA model B30, an early solid-state design using germanium transistors, and it was her constant companion.

The AWA B30 doesn't quite fit into the pocket-size category and nor does it rate as a mantel radio. Instead, it's a portable radio that's easily carried around without effort and it was perfect for grandma.

I remember having to occasionally change the set's battery for her, as her engineering skills didn't extend to that task. Other members of the family did likewise as required. I sometimes wonder what happened to her radio and my memories of it were recently revived again when I received one of these sets for repair.

The basic design

The AWA B30 was quite a small set by the standards at that time, a handspan dial and a roller volume/power switch being the only controls. Inside, the parts were mounted on a small PCB and the set had a 70mm-diameter loudspeaker. The case is covered in "genuine leather", according to a label on the base.

The original battery was a long 9V pack which was mounted under the PCB. These batteries are no longer available but can be replaced by a 9V type 216, as typically used in smoke alarms. I usually replace the battery plug with a snap connector to suit the type 216 and always fit an alkaline battery, as these are now available quite cheaply and have quite a long life in this application.

A piece of plastic foam can be cut to fill the large space left when installing this battery type, to hold it in place and stop it from rattling around inside the case.

The manufacturer's specifications state the set's dimensions as 4-5/8 inches (117mm) high, 7-3/16 inches (182mm) wide and 2-1/8 inches (54mm) deep, while the weight is two pounds (a bit less than 1kg). The set uses a standard 455kHz IF (intermediate frequency) stage and tunes the AM broadcast band range from 525-1650kHz.

At the time, Australian radio manufacturers were under considerable pressure to produce low-cost radios and TVs in order to compete with Asian imports (mostly from Japan). This little radio demonstrates just how well the AWA engineers met that design goal, as the set's performance is excellent, especially given its relatively simple circuit.

Basically, the set's main limitation is its modest 150mW power output and its tiny 70mm speaker. As a result, it's easily driven into audio overload on a strong signal although it's probably satisfactory for its intended use.

Circuit details

The circuit design is fairly conventional and uses seven PNP germanium transistors – see Fig.1. It consists of a 2N412 mixer/oscillator (VT1) followed by two 2N1634 IF amplifiers (VT2 & VT3) and then an audio amplifier stage consisting of three 2N408s (VT4-VT6).

The signal is picked up by the large loopstick antenna (TR1) and is tuned by variable capacitor C1 which is one section of the 2-gang tuning capacitor. The other section (C5) is connected across the local oscillator coil (TR2) and tunes the local oscillator frequency.

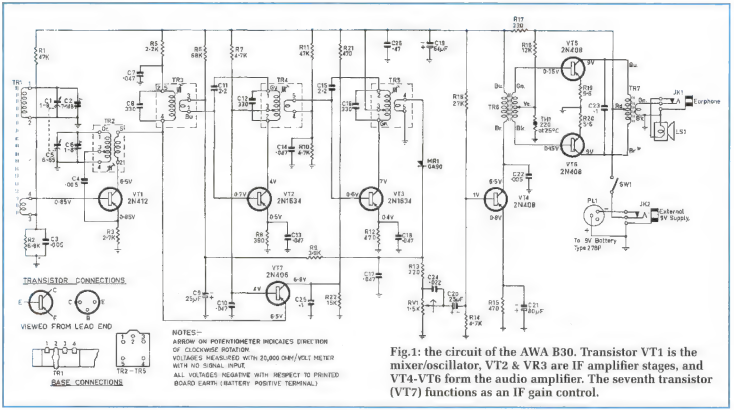


Fig.1: the circuit of the AWA B30. Transistor VT1 is the mixer/oscillator, VT2 & VR3 are IF amplifier stages, and VT4-VT6 form the audio amplifier. The seventh transistor (VT7) functions as an IF gain control.

The resulting 455kHz IF signal from the mixer/oscillator is fed to IF transformer TR3 and then to IF transformers TR4 & TR5, via IF amplifier stages VT2 & VT3. The signal is then fed from TR5 to the detector diode which is a germanium type OA90 and the detected audio then fed to volume control RV1 via a 220Ω resistor (R13).

In addition, the output from the detector is filtered using R9 (3.9kΩ) and C9 (25µF) to provide the AGC signal. This is then applied to the base of VT2 via IF transformer TR3's secondary.

The first 2N408 transistor (VT4) is used as an audio preamplifier and this drives a phase-splitter transformer (TR6) and then two more 2N408s (VT5 & VT6) which operate in push-pull. This push-pull output stage then drives the speaker via another centre-tapped transformer (TR7). A headphone socket (JK1) is wired in parallel with the speaker and automatically switches the speaker out of circuit when a set of headphones is plugged in.

The seventh transistor in the circuit (VT7) is a 2N406 and this serves as an IF gain control.

A voltage divider consisting of a 12kΩ resistor and an NTC thermistor (TH1) provides the base bias for the output stage. As its temperature increases, the thermistor's resistance falls and the bias automatically reduces. This ensures a fairly constant quiescent collector current in the output stage regardless of temperature changes and eliminates the possibility of damage due to thermal runaway.

The two 5.6Ω emitter resistors provide some local feedback and help balance the differing gains in the two output transistors.

Finally, the circuit has provision to accept an external 9V power supply via jack socket JK2. The internal 9V battery is automatically switched out if an external supply is connected.

Low gain

In operation, the limits of the germanium PNP transistors used were easily reached due to their low gain and modest frequency response. In fact, the low RF frequency gain of early germanium transistors was their main limitation and it meant that two IF amplifier stages were required to achieve reasonable performance from the radio.

It's interesting to note that all the transistors in this radio were manufactured in-house under the AWV brand. Amalgamated Wireless Australasia Ltd (AWA) was a huge organisation at that time and manufactured almost all the parts used in their radios and other products. Many of these products were equal to, if not better than, similar products produced elsewhere in the world.

Servicing the set

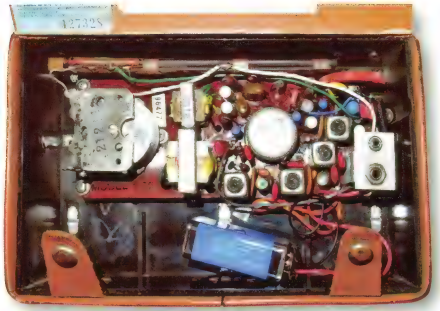
When I received this radio, it was a 'non-goer' in that it wasn't picking up any radio stations. It also had a rather noisy volume control but at least that indicated some life in the audio section.

A common fault with all old electronic equipment is failure of the electrolytic capacitors; they dry out and go open-circuit. A visual inspection usually reveals the rubber end seal is swollen and sometimes the electrolyte paste has spewed out.

As a normal precaution with old equipment, I always start by replacing all the electrolytic capacitors and that will often restore a faulty set to normal operation. In the interests of reliability, I usually use tantalum types where possible as the cost difference is not great and they will probably never need replacing again.

If electrolytic capacitors are necessary (eg, for values above 100µF), then I always try to use 105°C capacitors as they are more reliable.

So, following my standard practice, I duly replaced all four electrolytic capacitors: C9, C19, C20 & C21. This



Most of the parts inside AWA B30 transistor radio are mounted on a densely-packed PCB. The original long 9V battery pack used in these radios is no longer available but a type 216 9V battery (wrapped in foam to stop it rattling) can be used instead.

immediately restored the radio to working order but this success was short-lived because the audio suddenly faded away until it was almost inaudible. Switching the set off and on brought it back to life again but with the same result.

Based on the symptoms, I initially thought that it must be a faulty battery but a quick check with a digital multimeter quickly disposed of that theory. The DMM indicated that the full 9V rail was still present at the on/off switch after the signal had faded.

My next test was to inject a 455kHz signal from an RF signal generator into the set. To my surprise, holding the generator leads near the loop-stick antenna suddenly restored the radio to normal operation. This was puzzling but suggested a fault in the local oscillator circuit.

All the voltages around this stage measured OK, so I decided to try replacing oscillator coupling capacitor C4 (.005μF) in case it was faulty. Old capacitors often become leaky due to a breakdown in the paper insulation that was commonly used before polystyrene capacitors became available.

Unfortunately, changing C4 made no difference, the signal again fading away within a few seconds and a 455kHz signal injection then bringing it back to life as before. As a result, all the resistors in that section were checked but were found to be within tolerance. This was going to be a challenge.

A detailed voltage check subsequently revealed a very low voltage on the collector of the first IF amplifier transistor – just 1V instead of the 4V specified on the circuit. Replacing the resistor supplying the collector circuit (R7, 4.7kΩ) did nothing and the only other component left was bypass capacitor C10, a 0.047μF ceramic type. Replacing it cured the fault and the restored normal performance.

I subsequently checked the faulty capacitor on my DMM and it measured OK, both in regards to its capacitance and its leakage resistance. So the fault was obviously evident only when a DC voltage was applied to it.

As a precaution, I now decided to replace all other capacitors of the same type, to ensure long-term reliability. This is not the first time I have experienced unusual faults in old radios due to these capacitors. They really can cause problems which can be difficult to diagnose.

By the way, these capacitors are rated at 25V, so the failure is obviously not due to over-voltage as the battery supplies just 9V. That means that the failure is in the ceramic material that's used as the dielectric.

It's also interesting to note that I haven't observed similar ceramic capacitor failures in any of the Asian-manufactured equipment that I've serviced in large numbers. The problem only seems to occur with Australian-manufactured ceramic capacitors from that era. In fact, apart from those used in Australian radios, I have always considered ceramic capacitors to be completely reliable and so I usually ignore them when diagnosing faults.

A squirt of contact cleaner on the noisy volume control cured that particular problem in the old AWA B30. As a final check, I then injected a 455kHz signal from my generator and tweaked the IF transformer alignments. This further improved the sensitivity of the radio and it turned out to be quite a good performer.

It was then just a matter of reinstalling the PCB assembly in its case and giving the leather a good clean. The accompanying photo shows the result.

Design comments

The PCB assembly in this radio is very compact, with the parts jam-packed together and the resistors standing on their ends. This can make component replacement a difficult operation. The components are also relatively large by today's standards, which further adds to the impression of a crowded circuit board.

Typically, the copper tracks on PCBs used at that time were sensitive to overheating when parts were installed or, more particularly, when they were being removed. The tracks peel away from the board laminate quite readily if too much heat is applied, so it is necessary to always use a temperature-controlled soldering tool, set as low as possible.

It's also important to work quickly, to avoid overheating the pads and tracks. I always have a good supply of solder-wick handy to speed up component removal, especially for early Australian-made equipment. After all, preventing the track from lifting in the first place is better than trying to patch a damaged track.

Asian-made equipment is less prone to PCB track damage but this warning still applies to all early PCBs. I have seen too many tracks damaged in all sorts of equipment by people who have been too enthusiastic with a soldering iron.

Finally, there is great satisfaction in getting an old radio like this going again. If you have one on a shelf in your home, why not give it a new lease of life? SC

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CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$35.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (New V2 PCB)	APR (DEC) 2012	10105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PICAVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$20.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08109121	$10.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	**$15.00**
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$30.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	**$25.00**
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	**$25.00**
BARKING DOG BLASTER	SEPT 2012	25108121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	09110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110122	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
USB POWER MONITOR	DEC 2012	04109121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$25.00
GEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102131	**$30.00**
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	**$25.00**
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-455MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106131	$15.00
L'IL PULSER MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107130	$10.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IPOD CHARGER	AUG 2013	14108131	$5.00
PC BIRDIES	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$10.00
BATTERY LIFESAVER	SEPT 2013	11108131	**$4.00**
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SIDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	**$30.00**
SIDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$25.00/pr
TINY TIM AMPLIFIER (same PCB as Headphone Amp (Sept11))	OCT 2013	01309111	**$20.00**
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	05112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS (for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above (Nov 2012/May 2013))	DEC 2013	01111131-5	$35.00/set
LED PARTY STROBE (also for Hot Wire Cutter (Dec 2010))	JAN 2014	16101141	$7.50
BASS EXTENDER Mk2	JAN 2014	01112131	$15.00
L'IL PULSER Mk2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	**$12.50**
NICAD/NIMH BURP CHARGER	MAR 2014	14103141	$15.00
PRECISION 10V REFERENCE	MAR 2014	04104141	$5.00
RUBIDIUM FREQ. STANDARD BREAKOUT BOARD	APR 2014	04105141	$10.00
USB/RS232C ADAPTOR	APR 2014	07103141	$5.00
NEW THIS MONTH:			
MAINS FAN SPEED CONTROLLER	MAY 2014	10104141	$10.00
RGB LED STRIP DRIVER	MAY 2014	16105141	$10.00
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Higher power from 12AX7 preamp supply

I have been looking at one of your older 12AX7 preamp circuits, from the November 2003 issue. I am interested in the power supply circuit for it. Do you think it would be possible to achieve say 300V DC @ 20-30 milliamps? Could you tell me the frequency the power supply works at and the maximum HT current it could deliver? (J. B., via email).

● The power supply in the November 2003 12AX7 valve preamp should be capable of delivering an output of 25-30mA at 300V. To achieve that output voltage, you may need to change one of the resistor values in the feedback divider, however. We suggest reducing the value of the 47kΩ resistor to say 39kΩ and perhaps also reduce the value of the 220kΩ resistor in series with VR1 to 180kΩ.

The operating frequency of the DC-DC Converter is 33kHz.

Car radio entertainment system query

I like the idea of the Car Radio Entertainment System, to get something with decent sound, as everything is so tinny these days. However, I have some reservations about the design since some switchmode supplies have vent holes in the top. You have the wadding crammed over the top of the supply.

Other than that I would not put one in a sealed cabinet. Going on the short life of some switchmode supplies, they must be working on tight component tolerances, so the cooler you can keep them the better. (S. R., via email).

● We think you might be referring to an "open frame" power supply which has a perforated mesh top cover. The type of switchmode power supply we suggested is totally encapsulated and has no ventilation holes. And since the current drain of the car radio will usually be far lower than the supply's maximum rated power output, the supply should run quite cool to the touch.

Nevertheless, we agree that if the power supply has a tendency to run warm (or hot), it would be unwise to put wadding on top of it.

Old stereo preamplifier not recommended

I came across the circuit for the Playmaster 112 Stereo Control Unit in the December 1965 issue of *Electronics Australia* magazine. I like the design, wiring layout and impressive specs, even compared with the later 1969 design. I also like the tone control section. Strangely it seems to give better boost and cut compared to the later Playmaster variations. I have managed to source all the parts but will have to "build" the earthing plate for the input rotary switch.

My only query is can you guide me as to the value of the preamplifier feedback resistor for my ADC XLM cartridge? Its output is quoted as 6mV whereas the sensitivity of the disc input is a healthy 1.5mV. Values of 4.7MΩ to 470kΩ are suggested but I have no idea of the range that this covers nor what a high-output magnetic cartridge would produce back in 1965. (L. G. Cowes, Vic).

● Your preamp feedback resistor should be reduced to the minimum possible to give you just adequate gain with the cartridge you have. We suggest you try 470kΩ to begin with but if possible, use an even lower value, such as 270kΩ or 330kΩ.

The reason we emphasise going for the lowest possible feedback resistor is that this preamplifier circuit simply does not have adequate overload margin for typical magnetic cartridges which can produce more than 100mV at peak recorded levels.

Can The Induction Motor Controller Run At 3000 RPM?

Would it be possible to increase the output speed of the Induction Motor Speed Controller to more than what can be set now with the over-speed setting? I have the older kit with the first modifications and it works very well.

There were some ramp-up errors that made the motor start up and move up to under full speed then drop to a slower speed than set. I also made some small holes for the LEDs in the lid to provide some indicators for the unit.

My motor runs at 1436 RPM from 240VAC mains, while with the Induction Motor Speed Controller it has a top speed of 2182 RPM at the maximum over-speed setting. I would like to push the speed up to between 2500-3000 RPM.

I am not sure if this can be done without some modifications. (A. R., via email).

● While it might be possible to get the Speed Controller to more than double the speed of your motor (by modifying the software), the amount of power available is likely to be quite limited by the motor's inductance.

If you really need a motor to run at up to 3000 RPM you would be better to use a 2-pole induction motor which will have a nominal speed of about 2850 RPM. It will then be able to be controlled over your designed range without any modifications to the software. By the way, most bench grinders are 2-pole motors with a nominal speed of 2850 RPM.

Finally, make sure that any LEDs protruding through the lid are above the low-voltage section of the PCB and that there's no chance of any of their connecting leads coming into contact with remainder of the circuit which operates at 230VAC.

Stereo DAC May Have Faulty Decoder IC

I'm putting together the Altronics K5332 Stereo DAC Kit (original version from 2009) but can get no output from the input board. The Sony DVD Player's optical output has been tested with a Jaycar DAC (Cat. AC-1631) which we commonly use at work to provide RCA audio outputs for TVs without this facility.

LEDs 4 & 5 do not come on. The blue LEDs 1, 2 & 3 are OK and go through the described working sequence flawlessly, except that an optical signal plugged into TOSLINK receivers 1 or 2 is not detected.

Switching manually to the appropriate input results in a scope showing signal to pin 20 of IC3 (input) but none leaving pin 12. Oscillator IC3 appears to be OK and the various clocks are output from the digital I/O socket on pins 4, 6 & 10. IC3 pin 1 (AUDIO) is low and pin 27 (ERROR) is high (+3.3V).

I am assuming the pre-soldered IC3 (DIR 9001PW) is faulty and will need replacing (available from Element14, 39-0699 or 175-4823). Any better ideas? Maybe I have missed something obvious. (J. E., via email).

● It could be that your DIR9001 IC is faulty however you should try to rule out other potential problems before going to the effort of replacing it.

It sounds like reset has been released since you are seeing clock output. Do you have a source of coaxial S/PDIF to test the unit with? It could be that the signal from the optical receiver modules is somehow being corrupted and the chip is simply not able to lock on to the stream.

You should also check the values of the components on the FLT pin. There was a mistake in the original design where the filter resistor was specified as 6.8kΩ when it was supposed to be 680Ω. Check also that the values of the 68nF and 4.7nF capacitors are correct, if you can. If the PLL loop filter is not working correctly, the results could be as you describe.

You could also try temporarily removing IC2 from its socket and bridging one of the input pins (14, 15 or 12) to pin 13 to see if the problem is signal distortion due to the multiplexer IC (unlikely but easy to rule out).

If you are sure the filter components are correct and a clean signal is getting to IC3, the clock outputs are valid but the ERROR pin is still high, then there seems to be a problem with IC3. You could carefully examine the soldering with a magnifying loupe in case it is simply a soldering problem that could easily be fixed. Failing that, remove and replace this IC and hopefully it will then work correctly. Just be careful not to overheat the board while doing this or you could damage some of the small solder pads.

Even after you do that, the simple bias network for the input transistor means that the preamp is unlikely to clip symmetrically at maximum output. Many preamplifiers from this era were inadequate in terms of overload margin and accuracy of the RIAA compensation, the latter being caused by insufficient open-loop gain from the transistor feedback pair and less than optimum selection of the components in the simple RC feedback network.

To be frank, this is a 50-year old design which might have been OK (compared with valve preamps of the time) but it is a poor performer, even compared with designs from 30 years ago such as the Playmaster 60/60, from 1986.

At the very least, we suggest substituting the Universal Preamplifier from our May 1994 issue or preferably, the far superior Magnetic Cartridge Preamplifier from the August 2006 issue. It will be far quieter and have much lower distortion (measured and audible) than the Playmaster 112 and its overload margin is more than adequate for all magnetic cartridges. We can supply the PCB for the latter design and all the parts are readily available.

By the way, you probably should also replace the stylus assembly on your old magnetic cartridge. Not only is the stylus itself likely to be worn and therefore likely to cause groove damage to your records but the compliance of the suspension is likely to be very low, ie, very stiff. If you cannot get a new stylus then we strongly recommend the purchase of a new magnetic cartridge.

Noise filter for Precision 10V Reference

From the article in the March 2014 issue, I have read about some residual noise being superimposed on the output of the Precision 10V Voltage Reference Mk2.

In the circuit "10.000V Standard" on page 528 in the book "Encyclopaedia of Electronic Circuits Volume 7", a series network of a 49.9Ω resistor and a 0.47μF capacitor is placed across the output and ground of the voltage reference, which provides stability when cables and capacitive loads are being driven.

The aforesaid capacitor is usually a low-voltage polyester unit and you can usually get away with a 47Ω 1% resistor instead of a 49.9Ω unit. Has such a network been tried on the output terminals on the PCB of the Precision 10V Reference Mk2 (if necessary, changing the aforesaid component values) and if so, has it increased output stability? (B. C., via email).

● We have not tried connecting a series RC or 'Zobel' network across the output of the AD587 device in the Precision 10V Reference Mk2 because, as noted in the specifications panel, its output noise figure is already significantly lower than previous devices – at less than 4μV p-p and typically around 2μV peak-to-peak.

Connecting such a network across the device may result in lowering this noise level even further, and probably will not have any adverse effect on stability. So by all means try this approach, if you believe that "less than 4μV peak-to-peak" is too high for your application.

Speed controller pot has reverse effect

I recently constructed a "12V-24V High-Current Motor Speed Controller" kit from Altronics, as described in the March & April 2008 issues. When testing it on the bench with a small 15V variable power supply and a small motor (about 1A maximum con-

LED Musicolour Needs An Amplifier To Drive Speakers

I am a Year 12 student currently studying VCE systems engineering. For my project this year I am hoping to build a speaker box (dock) with strips of LEDs that flash to the beat of the music

I have two 10W speakers which I would like to mount together on a box with LED strips across it and all the wiring inside the box. I am enquiring about whether I can use your LED Musicolour kit to power the LEDs.

Would this be feasible to power the two speakers if I wire the speakers directly from the line out of the Musicolour? Or would I need to purchase an amplifier and if so how would I go about wiring it to the Musicolour and speakers? Is it feasible to send sound to both speakers and where can I purchase all the components of the kit? (L. E., Ballarat, Vic).

● You could drive speakers straight from the output of the LED Musicolour but you would need to put 8-ohm resistors in series with the outputs as the specified minimum load resistance of the WM8759 chip is 16 ohms. And the sound wouldn't be very loud or very high quality; it's only designed to drive headphones at 50mW and with those resistors, the speakers would only be getting 25mW. They would have to be quite efficient speakers to get a decent volume out of them.

We suggest instead that you use our Compact 12V Stereo Amplifier, described in May 2010. Altronics has a kit (Cat. K5136). Then it's simply a matter of connecting the output of the LED Musicolour to the input of this unit using a 3.5mm stereo jack plug to 2 x RCA plug cable. The amplifier and LED Musicolour can run off the same 12V supply, although if you do so you may find that LED switching noise makes it through to the amplifier via the common ground connection. Separate power supplies would solve this and a low-value resistor in the power supply ground to the amplifier might help too.

The LED Musicolour is stereo so you certainly can and should send sound to both speakers but as noted, you will get much better results with an amplifier.

Altronics also has a complete kit for the LED Musicolour (Cat. K5804). All you need to add are the DC power supply/supplies and LED/LED strips to be driven.

sumption), I found that most functions worked as described but a couple of features seemed unusual when setting the speed.

I noted that full clockwise rotation of the pot resulted in minimum speed and fully anticlockwise was maximum. I said minimum because although the motor stopped it was not quite down to zero and the motor was singing quietly at the switching frequency. I checked the voltage at link 16 and found it to be 5.00V, exactly the same as at link 17.

Disconnecting the motor dropped the speed percentage to zero as expected. The software version is 3.0 and while a reset to defaults made a small improvement, the speed was still not zero. Is this considered normal operation?

The other point that I would to make is that when the controller is mounted in the vehicle it is going to control, great care will have to be taken when making changes using the display board, to avoid the vehicle leaping into action when exiting a menu item that has the motor disabled. (C. B., Maryborough, Qld).

● It's strange that clockwise speed pot rotation does not give an increase in speed but instead a decrease in speed. The software options (which are rather complex in this project) could have facility to swap the 0-5V from the speed pot to operate in the opposite direction to give clockwise for faster speed.

The off speed setting should switch to fully off, as this is a "feature" of the controller. Perhaps if the off position for the speed was at 0V rather than 5V, this would work.

If the option to swap the pot rotation action is not available, some experimentation with the back-EMF resistor (33kΩ at pin 1 of IC1) may bring the pulse width drive to zero at the zero speed setting. You could try a larger value such as 47kΩ. It may also be that the small 1A motor you are using is not suited for this controller with the back-EMF resistor values in the circuit.

Finally, if all else fails, the pot could be removed from the PCB and wired so that there is increased speed with clockwise rotation.

RIAA preamp for the mini entertainment unit

I am writing with regard to the Mini Entertainment Centre featured in the February 2014 issue. I have an old hifi unit that has failed, as one channel of the amplifier output no longer works. As the cabinet is a reasonable piece of furniture and because the speakers are OK, I am considering replacing the radio/amplifier with a car radio similar to your project.

The only catch, although not critical, is that my hifi unit also has a turntable for records. I have noticed most modern car radios have an "Aux In" socket on the front panel (as does the Sony unit you purchased). I am wondering if this input would be suitable for the turntable output (which comes directly from the stylus) or does this signal need further conditioning? (A. D., via email).

● The Aux input is not suitable for a turntable which has a magnetic cartridge. For this, you will need an RIAA preamplifier such as our design from the April 1994 issue. This is available as a kit from Jaycar: Cat KC-5159.

1ms interface wanted for speed control

I purchased the Simple 12V Speed Controller kit (Silicon Chip, November 2008) and it works very well driving a little motor. What I would like to do is incorporate this into my model plane as a 'Smoke Pump Control'.

Is there any available chip that will allow my 1.2ms pulses to be interfaced directly into this unit thus not using the pot connected to the servo. Could you kindly share your thoughts on this? (D. R., Pannawonica, WA).

● We have checked through the circuits we have published and there is nothing that is appropriate to your

application. Nor is there any specific chip to do the job.

What is really required is a 1ms to DC converter which could then be interfaced to the speed control in question. The best way to do that would be with a PIC microcontroller.

Step-down power supply for glow plugs

I was hoping you might be good enough to help me with a problem. I fly radio control planes which run on methanol. These engines rely on glow plugs to work and at times it becomes necessary to run an on-board glow battery. Even though there are a number of these available commercially, they all run on a single D-size battery and as a result you need to keep the leads to the glow plug very short or it simply will not light the plug. Unfortunately, that is not always possible.

My query to you is, would it be possible to use a 4-cell Nicad or NiMh battery pack and step it down to 1.5V @ 3A? This is required to run these glow plugs as this type of set-up would not be so vulnerable to the length of the leads. I have tried using an LM317 regulator but it got too hot.

I would like to use a 555 timer and chop the voltage down to 1.5V but I'm not sure on how I would do that. Using a 555 may also be possible to make it self-adjustable in current which would be helpful when it comes to wet plugs, ie, when the engine has been flooded.

Is this possible to do and could you guys steer me in the right direction on how to go about it? (T. P., via email).

● Using a 555 timer to step the voltage down to 1.5V will not work as it does not have sufficient switching capacity. We suggest using an LM2678T-ADJ switchmode regulator. This can be adjusted to give 1.5V at 3A and should not get hot. The parts and data are available from Jaycar. It will run from three cells in series.

The 8V input in the sample circuit in the data sheet is only for 5V out. For 1.5V out, the input can be lower. The diode can be an MBR735. The output capacitor could be a 100µF as you would not be concerned about ripple.

Driveway Sentry has loop fault

I recently built the Driveway Sentry Mk2 but have not had success with it. The board itself seems to be working fine as I can generate an event when I check for continuity across the ends of the induction loop with my multimeter. It seems that the loop is the problem.

I originally built the loop with 35m of wire that I had in stock, which was 8-core screened data cable in a twisted pair configuration. This I formed into a continuous end-to-end loop as per your specified method. Using this loop the unit partially worked on the bench and I was able to get an inconsistent event from a large iron bar or a golf club. When I set it up in the driveway, the car wouldn't trigger anything.

Solving Poor Signal From Caravan Video Camera

I have my vehicle fitted with a reversing camera which works fine. I have added one to the rear of our caravan with a switch to select either. The van image is weak and washed out, obviously due to losses in the long cable.

I figure if I fitted a video amplifier to the van I would overcome the problem. Have you ever published an article on a simple 12V colour video amplifier that would solve my problem? (P. M., via email).

● A video amplifier may fix the signal loss but signal quality may still be poor due to high frequency roll-off of the signal through the shielded cable. We did publish a video transmitter and receiver in October 1996 using twisted pair cable with a 1.5km range but this is now outdated and there are cheaper alternatives now available.

For long runs, a video to Cat5 balun and a Cat5 to video balun can be used and these are quite cheap and very effective. They allow transmission of video through Cat5 cable over 400m; more than adequate for most vehicle and caravan total lengths. The units require no power.

One balun is located near the camera and another at the receiver screen. Cat5 cable is used for the long run between the baluns. The baluns are reversible for video input to Cat5 and Cat5 to video output.

Jaycar sell the balun set for $14.95 – see www.jaycar.com.au/productView.asp?ID=QC3660 You will need some Cat5 cable too. It uses BNC connectors for the video connections.

The BNC connectors could be changed to RCA types or you can simply directly connect the video camera output and the screen input to their respective baluns on the video side.

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Review: Tektronix MDO3054 Scope

. . . continued from p91

decode and view hi-speed USB packets (but you can't trigger on a content match).

Performance

Boot-up time is around 20 seconds which is par for the course with a scope having this many features. The next thing we looked at was analog noise performance which is good.

It's quoted as <150µV +6% of one division for bandwidths up to 200MHz or + 8% of one division up to 1GHz. In practice, the display is quite clean, especially in 'High Resolution' mode.

While the interface is easy to use, its responsiveness leaves a little to be desired. It can feel sluggish at times but is pretty tardy in spectrum analysis mode with a high ratio of span to resolution bandwidth.

Of course, you would expect the display update rate to be very slow as this involves a lot of calculations but we don't see why it has to stop responding to button presses during this process. And while the waveform acquisition rate is far from poor, it isn't the best we've seen either.

To get the full specified rate of 280,000 acquisitions per second you need to use "FastAcq" mode which changes the way waveforms are displayed (see Fig.2). Otherwise, the limit is 50,000 acquisitions per second.

We like that you can display statistics for each measurement (min/max/average/etc, see Fig.3) but unfortunately when you turn statistics off, you don't get that screen space back.

The rear panel carries the connectors for the arbitrary waveform generator output, a trigger output, Ethernet, VGA and two USB ports. One USB port is for connection to a PC while the other is for a printer.

The measurements are displayed in a vertical list rather than horizontally so with several on-screen, that uses up quite a bit of valuable real estate, despite the large display.

As a result of this and the large number of features in general, it's quite easy to clutter it up with so much information that you can barely see the traces (again, see Fig.3). But at least you can press "Menu off" a few times and turn off the zoom and some other functions and get the screen real estate back (Fig.4).

Conclusion

Tektronix have managed to combine a mixed-signal oscilloscope, spectrum analyser and arbitrary waveform generator in one package without really compromising any of those functions.

All of these features work well although it is a bit of a stretch to call it six instruments in one, as the protocol analyser functions are a pretty standard feature of the logic analyser and the DVM only provides a small increase in utility over the existing scope measurements.

Overall though, as you can gather from the above, they haven't skimped on features. While we would like the interface to be a bit more responsive, that doesn't really get in the way of its ability to view signals which is what this instrument is all about.

If you want a stand-alone scope with a proper spectrum analyser, Tektronix is currently the only game in town.

For pricing, for more information or to order one of these units, contact TekMark Australia on 1300 811 355, e-mail enquiries@tekmarkgroup.com or visit www.tekmark.com.au SC

I then remade the loop with the exact wire recommended in the article. This was worse as I was no longer able to create an event of any sort with bars or golf clubs. Any help would be appreciated. (M. M., via email).

● It certainly does sound as if the loop is the problem. But it's not easy to zero in on the exact nature of the problem itself.

If your multimeter shows that the loop conductors themselves are correctly wired as a continuous loop, with no segments reversed in polarity and no open joints, this would leave the outside screening braid. If this has been accidentally connected to ground at both ends (rather than only at one end), it would act as a shorted turn rather than a Faraday shield and would then prevent the loop from working.

Try disconnecting the loop shield connection at the righthand end terminal and then use your multimeter to see if there is still a connection between the two. If there is, this will show that there is still a connection, eg, at the other end of the loop cable.

Monitor for LiPo batteries

I am the proud owner of a new LiPo 100Ah battery. I intended to use two of these in my new caravan as house batteries, charged by solar, an AC battery

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charger and a Redarc DC-DC charger from the tow vehicle's alternator.

What I am trying to do is monitor/control the charging/discharging of these batteries. Some time ago, I built the Voltage Switch project from your "High Performance Electronic Projects for Cars" book (chapter 12). I thought I could set this up to trigger the relay once the battery voltage dropped below 11.5V and also once the battery voltage rises above 14.5V. This would allow me to protect the battery from damage due to under and over-voltage situations.

Can you suggest a way of modifying this project to achieve these functions. I realise of course I could build two of these, one to trigger an alarm for under voltage and the other for over voltage.

Any suggestions you can make would be appreciated. (J. G., via email).

- You would be able to use just one voltage switch with the settings in the H/L position for LK1 and also for the diode. This will have the relay switch off when the voltage goes above 14.5V. Use VR1 to set this trip point.

The hysteresis setting with VR2 is

continued next page

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. . . continued from page 103

then adjusted for switch-on, again at 11.5V. Some trial and error is required for these adjustments using a variable power supply.

If a variable supply is not available, use a 15V supply with a 10kΩ linear potentiometer across the supply. The wiper is then adjusted for the test voltages and applied to the signal voltage input on the Voltage Switch.

We are planning to update this project next month, with a new PCB and a 30A relay.

Simple digital 230VAC timer wanted

I was wondering if you had created in the past a simple 230VAC count up/count down timer. I want to be able to turn on a 230VAC device in X hours time, or turn off a device in X hours time, as set by a mode switch. Once triggered its state does not change until reset.

I am looking for a device that has the following controls: (1) a button/switch to set mode to count up/down; (2) a pushbutton to set the timer values, ie, +1 hour each time it's pressed, to a maximum of 23 hours from now; (3) a simple 2-digit display showing the hours selected; (4) a start/reset button and (4) up to 10A capability, all in a nice compact box!

I can't find anything on the market that does it. Yes, you can buy programmable timers with lots of on/off programs but they are far too hard to use. I need something that I can use with almost a zero learning curve, ie, just plug the device in, set the timer, and forget. (N. M., via email).

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- We have published numerous timers but none that are as simple to use as you describe with just hour steps. Most of our timers have minutes and hours adjustments.

You may be able to obtain a salvaged mains timer from a clothes dryer, heater or microwave oven. Some timers are electromechanical and use a mains synchronous motor to drive the timer. More basic ones use a clockwork timer and contact switch. Others are electronic and will require a low voltage power source instead.

You then use the switching contacts to drive a relay that has changeover contacts. Depending on the contact arrangement, the timer can either switch on or switch off an appliance with the timer. SC

Notes & Errata

1.5kW Induction Motor Speed Controller (April & May 2012): there is now a more rugged IGBT bridge with higher current ratings available as a drop-in replacement for the originally specified STGIPS20K60. The new device is the STGIP30C60 and it has a rating of 30A (up from 20A). The total power dissipation ratings are unchanged.

We recommend that all new speed controllers now be constructed with the new device, as the upgrade will provide increased reliability.

However, we do not recommend that readers use it with a motor or pump rated in excess of 1.5kW. In those cases where the speed controller will not reliably start a pool pump with the new IGBT bridge fitted, it will be possible to reduce the value of the specified shunt resistor from 15 milliohms to 12 milliohms to provide for more starting current.

Dual Channel Audio Delay (November 2013), Stereo Echo & Reverberation Unit (February 2014): IC2 must be a WM8731. Do not use the specified alternative part (TLV320AIC23BIPW) as this has the function of two pins swapped (21 & 22).

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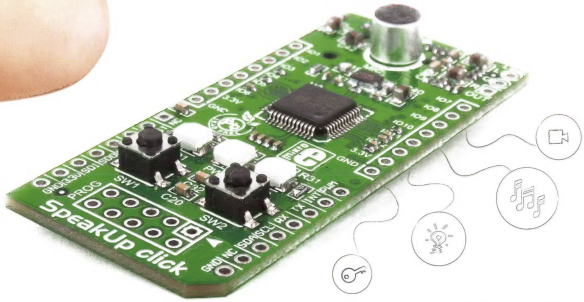

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